2024 AAPT

SUMMER MEETING

DATE :
JULY 6-10

LOCATION :
WESTIN BOSTON
SEAPORT DISTRICT

AAPT PHYSICS EDUCATION®

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Special Thanks

AAPT wishes to thank the following persons for their dedication and selfless contributions to the Summer Meeting:

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Contact:

Meeting Registration Desk: 301-209-3340

Facebook/Twitter at Meeting

We will be posting updates to Facebook and Twitter prior to and during the meeting to keep you in the know! Participate in the conversation on Twitter by following us at **twitter.com/AAPTHQ** or search the hashtag **#aaptsm24**. We will also be posting any changes to the schedule, cancellations, and other announcements during the meeting via both Twitter and Facebook. Visit our Pinterest page for suggestions of places to go and things to do in the Boston area. We look forward to connecting with you!

Facebook: facebook.com/AAPTHQ

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Committee Meetings

*All interested attendees are invited and encouraged to attend the Committee meetings with asterisks (*).*

Sunday, July 7

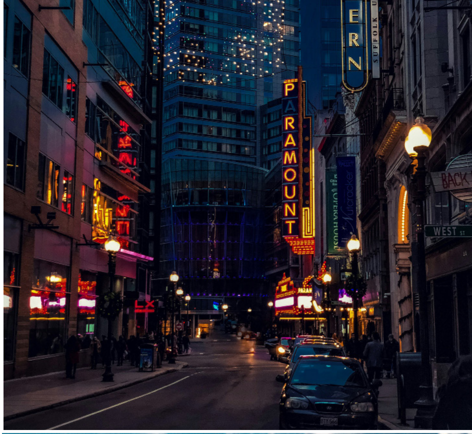
Meetings Locations Committee	1–2 p.m.	Faneuill
Awards Committee	1–2 p.m.	Adams
Publications Committee	2–3 p.m.	Grand Ballroom C
Nominating Committee	2–3 p.m.	Douglass
Governance and Structure Committee	2–3 p.m.	Quincy
MPC and AMP 24	3–4 p.m.	Faneuil
Area Committee Chairs	8–9 p.m.	Griffen

Monday, July 8

Diversity in Physics *	7:45–8:45 a.m.	Burroughs
Educational Technologies *	7:45–8:45 a.m.	Paine
History & Philosophy in Physics	7:45–8:45 a.m.	Quincy
Laboratories Committee *	7:45–8:45 a.m.	Hancock
Science Education for the Public *	7:45–8:45 a.m.	Commonwealth C
Physics in High Schools *	7:45–8:45 a.m.	Revere
Finance Committee	7:45–8:45 a.m.	Webster

Tuesday, July 9

Bauder & Venture Committee	7:45–8:45 a.m.	Hancock
Graduate Education in Physics *	745–8:45 a.m.	Independence
International Physics Education *	7:45–8:45 a.m.	Griffin
Physics in Undergraduate Education *	7:45–8:45 a.m.	Carlton
Space Science and Astronomy*	7:45–8:45 a.m.	Revere
Teacher Preparation Committee *	7:45–8:45 a.m.	Adams
PERLOC *	7:45–8:45 a.m.	Webster
PTRA Oversight Committee	7:45–8:45 a.m.	Burroughs
PERTG Town Hall	6:30–7:30 p.m.	Independence
Apparatus Committee *	7:30–8:30 p.m.	Burroughs
Contemporary Physics *	7:30–8:30 p.m.	Lewis
Research in Physics Education *	7:30–8:30 p.m.	Revere
Pre-High School Physics Education *	7:30–8:30 p.m.	Griffin
Two-Year College Physics *	7:30–8:30 p.m.	Carlton
Professional Concerns *	7:30–8:30 p.m.	Adams
Women in Physics Committee *	7:30–8:30 p.m.	Stone
Physics Bowl Advisory Committee	7:30–8:30 p.m.	Commonwealth C





Jocelyn Bell Burnell is the Recipient of the Richtmyer Memorial Lecture Award

Jocelyn Bell Burnell

"Bursts, bangs and things that go bump in the night"

Monday, July 8

5:30 –6:30 p.m.

Grand Ballroom AB

Jocelyn Bell Burnell inadvertently discovered pulsars as a graduate student in radio astronomy in Cambridge, opening up a new branch of astrophysics—work recognized by the award of a Nobel Prize to her supervisor.

She has subsequently worked in many roles in many branches of astronomy, working part-time while raising a family. She is now a Visiting Academic in Oxford. She has been President of the UK's Royal Astronomical Society, in 2008 became the first female President of the Institute of Physics for the UK and Ireland, and in 2014 the first female President of the Royal Society of Edinburgh. She was one of the small group of women scientists that set up the Athena SWAN scheme.

She has received many honors, including a $3M Breakthrough Prize in 2018.

The public appreciation and understanding of science have always been important to her, and she is much in demand as a speaker and broadcaster. In her spare time, she gardens, listens to choral music and is active in the Quakers. She has co-edited an anthology of poetry with an astronomical theme – 'Dark Matter; Poems of Space'.

Named for **Floyd K. Richtmyer**, distinguished physicist, teacher, and administrator and one of the founders of AAPT, the Richtmyer Memorial Lecture Award recognizes those who have made outstanding contributions to physics and their communication to physics educators. The recipient delivers the Richtmyer Lecture at an AAPT Meeting on a topic of current significance and at a level suitable for a non-specialist audience and receives a monetary award, an Award Certificate, and travel expenses to the meeting.

The 2024 Fellows:

Jennifer Blue, Miami University, Oxford, Ohio

Juan Burciaga, *The Colorado College, Colorado Springs, Colorado*

Stephanie Chasteen, Independent Consultant, Boulder, Colorado

Brad Conrad, National Institute of Standards and Technology (NIST), Gaithersburg, Maryland

Tatiana Erukhimova, Texas A&M University, College Station, Texas

Stephanie Chasteen is the 2024 Recipient of the Lillian McDermott Medal

Stephanie Chasteen

Stephanie Chasteen is specifically recognized "For essential contributions in program development and evaluation and sharing the results of physics education research with the physics community that have proven to be an integral part of meeting the greater needs of the broad physics community, providing research-based and community-based knowledge responsible for equipping physics educators to build thriving programs at all levels aimed at best serving the needs of students."

Regarding her receipt of the McDermott Medal, Chasteen said, "I am deeply honored and grateful to receive this award and recognition for my contributions to our community's work. I have been passionate about science communication and education since my early days as a physicist and am proud that I have been able to bring my talents to accelerate improvements in physics education."

"My life pursuing excellence in physics education"

Tuesday, July 9

11:30 a.m.–12:30 p.m.

Grand Ballroom AB

Chasteen has made extraordinary contributions to physics education, having served as a consultant on over 50 STEM education projects, helping departments and faculty take up new practices that embrace educational innovations. Although many of her contributions have been as an external evaluator, she has also contributed significantly to educational workshop design and translating research to teaching practice in numerous settings.

Chasteen is passionate about the power of external evaluation to have meaningful impacts on the world. As an external evaluator, Chasteen worked behind the scenes to help project leaders enhance the impact of national-scale efforts such as the Physics and Astronomy New Faculty Workshop (NFW), Physics Teacher Education Coalition (PhysTEC), Get the Facts Out (GFO), and Effective Practices for Physics Programs (EP3) – as well as dozens of smaller projects. Her broad background and keen eye led her to make significant intellectual contributions to these projects along with concrete suggestions of how they can improve. Through external evaluation, she has brought a steady and powerful passion that has steered projects to higher impact and increased accountability within the projects themselves and to their sponsors.

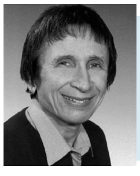
Chasteen received her Ph.D. in condensed matter physics from the University of California, Santa Cruz, followed by a postdoctoral fellowship at the Exploratorium science museum in San Francisco. She has been an activist in educational reform, sparked by her time at the Exploratorium and further informed by her time in the Science Education Initiative at the University of Colorado Boulder. Her communication skills were enhanced through an early career in science journalism, including an American Association for the Advancement of Science (AAAS) Mass Media Fellowship at National Public Radio.

In her role as a communicator, she has authored and made significant contributions to many enduring and influential works, including a podcast on teaching and learning physics, popular articles hosted by PhysPort, the assessment section in the EP3 Guide, the Science Education Initiative Handbook, and the influential white paper "How to work with external evaluators," hosted on the AAPT website. Her impressive h-index of 20 and more than 1800 citations on Google Scholar underscore her standing as a thought leader in her field.

In her most recent work, she played a pivotal role in the redesign of the Faculty Teaching Institute (FTI, the successor to the New Faculty Workshop), shifting the focus of this workshop from hearing from multiple experts to organizing around developing reflective teaching practices. Because of her work on this project 100's of new physics faculty will start their teaching careers with more pedagogical knowledge and a reflective mindset, positively impacting 1000's of students.

Colleagues appreciate her careful attention to detail as well as her grasp of the big picture, ensuring that both the content and structure of her work is at once practical, useful, and actionable. She has, through her work on these many projects, been instrumental in driving departmental reforms and promoting the teaching profession and has had a profound and lasting impact on the landscape of physics education.

Although her career has unfortunately been curtailed due to health issues, she commented recently, "I consider the physics education community as family and am deeply appreciative to have this award serve as a lovely capstone of my career!" The community couldn't agree more in awarding her this high recognition of her life's work.



Named for Lillian C. McDermott, the Medal recognizes those who are passionate and tenacious about improving the teaching and learning of physics and have made intellectually creative contributions in this area. In 2021 AAPT Board of Directors voted unanimously to remove Robert A. Millikan's name from the award that recognizes "those who have made notable and intellectually creative contributions to the teaching of physics." The AAPT then sought nominations from AAPT members for renaming the award. Based upon nominations from members, the BOD unanimously approved renaming the award to Lillian C. McDermott.

Don Lincoln

Don Lincoln to Receive 2024 Klopsteg Memorial Lecture Award

Don Lincoln, a staff scientist at Fermi National Accelerator Laboratory, is prolific as a science writer, producer of video content for the general public, productive public speaker, and a strong supporter of educational content for teachers.

Regarding his selection to receive the 2024 Klopsteg Award Lincoln said, "I was honored to have been nominated and am surprised to have won. I've had two goals as a science communicator: to share with people the excitement of scientific discovery and to inspire my colleagues to join me. This award will help me do both of these things better."

A passionate popularizer of physics and astronomy Lincoln has penned several books for the public and students alike including *Einstein's Unfinished Dream: Practical Progress Towards a Theory of Everything* (2023), *Understanding the Universe: From Quarks to the Cosmos* (2004), *The Quantum Frontier: The Large Hadron Collider* (2009), and *Alien Universe* (2013). Having a far reach in his communications to the general public, he has written for *The Physics Teacher, Scientific American*, *NOVA*, *LiveScience*, *BigThink*, and *CNN*.

"What keeps me up at night: Unanswered questions in fundamental physics"

Tuesday, July 9

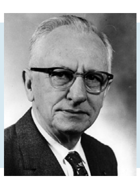
4:30–5:30 p.m.

Grand Ballroom AB

While his magazine articles are a potent influence and vehicle for communicating contemporary physics, perhaps Lincoln's most visible efforts are seen through his remarkable video presence. He is the presenter in over 150 YouTube videos for Fermilab's YouTube channel, with over 770,000 subscribers and 74,000,000 views. One of his most viewed episodes is "What is a Higgs Boson?" which is perhaps not so surprising since he was part of the team that is credited with the discovery of this fundamental particle. He has also produced several video physics courses for The Great Courses/Wondrium company, each 12 hours of content on modern physics topics.

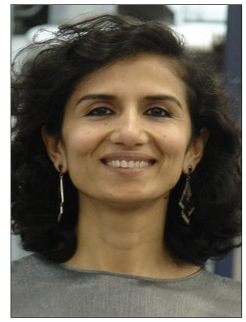
Also notable are his extensive public lecture appearances, which include several TED talks, and more recently, high profile presentations for New Scientist ("Fermilab: solving the mysteries of matter and energy, space and time") and the Chicago Comic and Entertainment Expo (C2E2, "The Science of Star Trek"). His popularity can be seen with his frequent collaborations with local science clubs (such as the Bay Area Skeptics), Society of Physics Students (SPS) regional student meetings, and his video content. His videos have been watched millions of times and are shown in undergraduate classrooms around the world.

This award recognizes educators who have made notable and creative contributions to the teaching of physics. Lincoln is recognized specifically "For passionate and profound career-long impact in sharing the excitement of contemporary physics topics in ways that interest and inform the general public about the relevance and importance of fundamental physics from cosmology to high energy particle physics through prolific and impactful communication and world-class public outreach programs."



Named for Paul E. Klopsteg, a principal founder, a former AAPT President, and a long-time member of AAPT, the Klopsteg Memorial Lecture Award recognizes outstanding communication of the excitement of contemporary physics to the general public. The recipient delivers the Klopsteg Lecture at an AAPT Summer Meeting on a topic of current significance and at a level suitable for a non-specialist audience and receives a monetary award, an Award Certificate, and travel expenses to the meeting. The award was established in 1990.

Chandralekha Singh Named as the 2024 J D Jackson Excellence in Graduate Physics Education Awardee



Chandralekha Singh

"Physics graduate education for the 21st Century{

Wednesday, July 10

9 – 9:30 a.m.

Grand Ballroom AB

The American Association of Physics Teachers (AAPT) has announced that the John David Jackson Excellence in Graduate Physics Education Award for 2024 will be awarded to Chandralekha Singh, Distinguished Professor of Physics, University of Pittsburgh, Pittsburgh, PA.

Singh is recognized for education research work that has profoundly impacted graduate physics education and scholarship in support of graduate physics education at the national and international level, born from her own prolific demonstration of skilled teaching and mentoring practices.

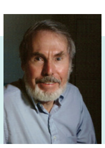
Singh earned her B.S. and M.S. in Physics at the Indian Institute of Technology, Kharagpur and her M.A. and Ph.D. in Physics at the University of California, Santa Barbara.

A Life Member of AAPT, Singh has served as a member of the various AAPT Committees, e.g., Committee on International Physics Education, Committee on Graduate Education in Physics, Committee on Women in Physics, Committee on Science Education for the Public and the Programs Committee. Her work in physics education research has produced high quality papers that have been published in journals such as the American Journal of Physics, Physics Today, and Physical Review. Singh co-edited three Physics Education Research Conference (PERC) proceedings and the May 2010 theme issue of American Journal of Physics focusing on the Gordon Conference on Experimental Research and Labs in Physics Education.

Elected to the Presidential chain of AAPT in 2018, she served as Vice-President, President-elect, President, and Past-President through 2022. As part of those roles she served as Chair of AAPT committees: Governance Structure, Review Board Committee, and Awards Committee. She was co-organizer of the first National Conference for all of the Past US Team Members to the International Conferences on Women in Physics, Provo (2019), and Chair, Program Committee, Summer AAPT National Meeting, Provo (2019), the Winter AAPT National Meeting, Houston (2019).

Regarding her selection to receive this award Singh commented. "I am truly honored and humbled to get this award. I have been a member of AAPT since the late nineties and I am incredibly grateful to AAPT for providing this stimulating community of educators who are passionate about improving the teaching and learning of physics at all levels."

Singh's pioneering research in the teaching and learning of quantum mechanics has played a significant role in advancing physics education research in advanced courses. In addition to educational research in advanced courses, she has conducted research on cognitive issues in learning physics, improving student problem solving and reasoning skills as well as improving equity and inclusion in physics learning environments. For a decade, she conducted workshops at the national AAPT meetings on "What every physics teacher should know about cognitive research" and on "Strategies to help women succeed in physics related professions." She has conducted workshops at the national and regional AAPT meetings on "Research-based approaches to improving student understanding of Quantum Physics." Singh has conducted workshops on teaching quantum mechanics during New Faculty workshops. She is also the co-organizer of the first conference on Graduate Education in Physics and chair of the second conference on Graduate Education in Physics.



The **John David Jackson Award for Excellence in Graduate Physics Education** is presented to physicists and physics educators who, like John David Jackson after whom the award is named, have made outstanding contributions to curriculum development, mentorship, or classroom teaching in graduate physics education. The recipient delivers an address at the AAPT Meeting at which the award is presented.

Tatiana Erukhimova

Tatiana Erukhimova to Receive the David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching for 2024

"It's not business, it's personal. Teaching large classes, one student at a time"

Wednesday, July 10

9:30–10 a.m.

Grand Ballroom AB

The 2024 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching winner is Tatiana Erukhimova, Instructional Professor and inaugural holder of Marsha L. '69 and Ralph F. Schilling '68 Endowed Chair in the Department of Physics & Astronomy, Texas A&M University. She received her PhD from the Russian Academy of Sciences in 1999 and joined Texas A&M University in 2001. Her approach to teaching can best be summarized by her 2018 keynote presentation at Texas A&M's Transformational Teaching and Learning Conference titled: "It's not business, it's personal. Teaching large classes, one student at a time." These words describe Erukhimova's sincere interest in the individual student and her investment fostering a strong sense of community with her students.

Regarding her selection for this award, Erukhimova said, "Over the years, I have learned how important it is to make every class interactive and memorable. How many of the students will consider my introductory physics class a highlight of their time here at Texas A&M? How many of them will remember it 20, 30, 40 years later? If there are quite a few, I couldn't imagine a better reward."

The culture of Erukhimova's classrooms is one of engaged, communal learning supported by innovative and research-backed pedagogy. She forms a community of mutual support where all students are expected to help each other learn. For content delivery, she uses a mix of engaging lecture, scaffolded problem-solving, peer instruction with in-class questions, and experimental demonstrations almost every day. Her courses personify the active learning encouraged by recent research. Students must be awake, engaged, and thinking at all times. The outcome of this, beyond students who are excited to be in class each day and courses which fill up long before other instructors, is students who learn and perform better in their courses.

Erukhimova's passion for student learning, combined with excellent classroom instruction, has earned her many awards throughout the years, including the Presidential Professor for Teaching Excellence in 2017, University Professor for Undergraduate Teaching Excellence (2021), American Physical Society Fellow (2019), The Nicholson Medal from the American Physical Society (2023), and multiple Association of Former Students awards (a high honor for faculty at Texas A&M).

Through her mentoring, Erukhimova has had a significant impact on students beyond her own classroom. In October 2014, she gave a series of presentations on effective teaching practices open to all graduate students in her department. Since then, she has been a mentor and advocate for graduate students who have opted to pursue instructional faculty positions at universities, offering them resources and materials, guidance and suggestions on course structure and pedagogy, and being an open ear and perspective for continuing advice.

In addition to her exceptional work in formal classes, Erukhimova has expanded and created multiple informal physics outreach programs designed to give students invaluable experiential learning opportunities beyond the classroom. Her signature program, Discover, Explore, and Enjoy Physics and Engineering (DEEP), created in 2012, involves undergraduate students working throughout the year in small teams led by graduate physics students to design and build interactive physics demonstrations. Then the students show them at the outreach events. These demonstrations become their legacy here at Texas A&M; some of them become part of the formal curriculum. The DEEP alumni started similar programs at Rice University and the UT-Austin.

Established as the Excellence in Pre-College Teaching Award in 1993 then renamed and endowed in 2010 by **Paul W. and Barbara S. Zitzewitz**, the **Paul W. Zitzewitz Award for Excellence in Pre-College Physics Teaching** recognizes outstanding achievement in teaching pre-college physics.

David A. Weitz, Plenary Speaker

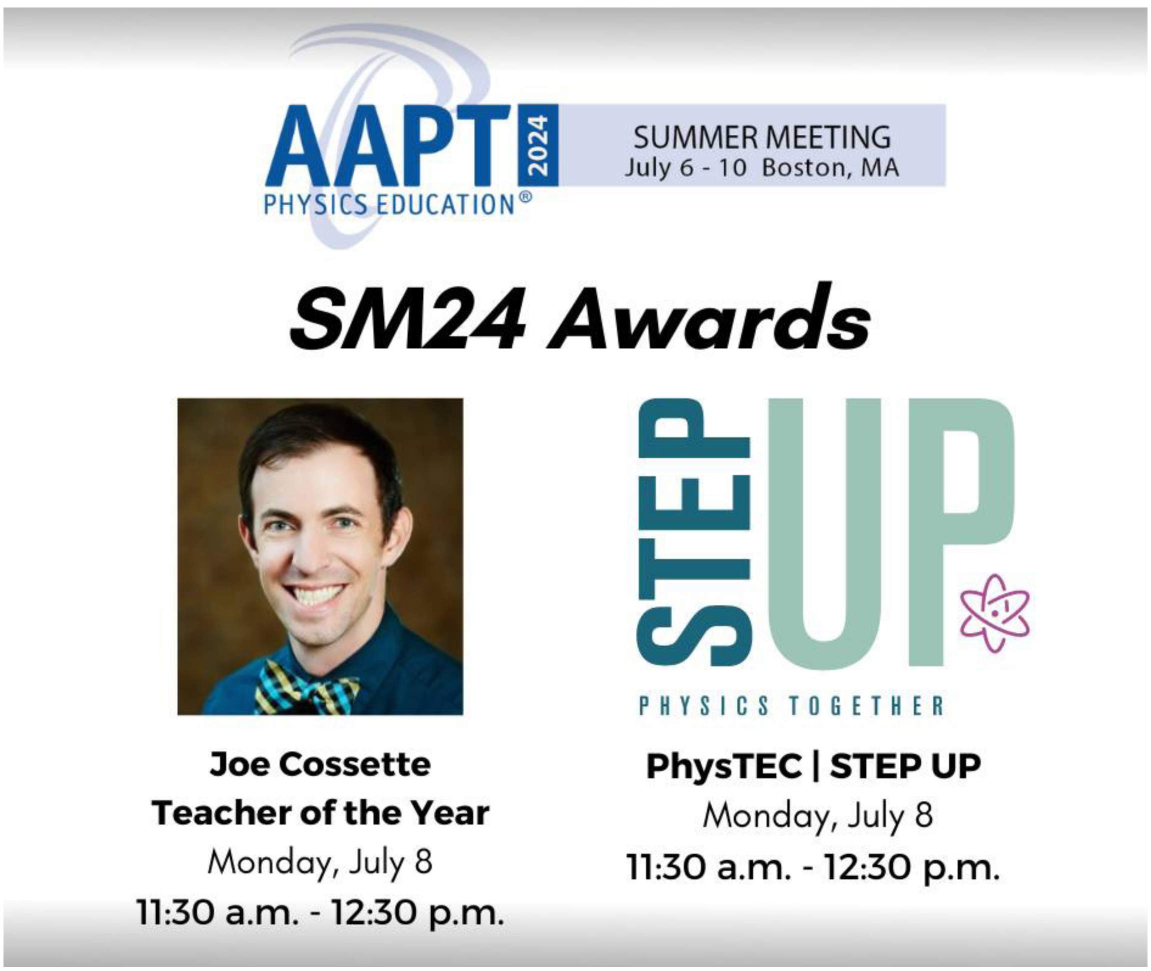
David Weitz

David A. Weitz is Mallinckrodt Professor of Physics and of Applied Physics at Harvard. Weitz's group studies the physics of soft condensed matter, materials which are easily deformed by external stresses, electric, magnetic or gravitational fields, or even by thermal fluctuations. These materials typically possess structures which are much larger than atomic or molecular scales; the structure and dynamics at the mesoscopic scales determine macroscopic physical properties. The goal of this research is to probe and understand the relationship between mesoscopic structure and bulk properties. We study both synthetic and biological materials; our interests extend from fundamental physics to technological applications, from basic materials questions to specific biological problems. The techniques we use include video image analysis, light scattering, optical microscopy, rheology, and laser tweezing. We also develop new techniques to study these materials; we pioneered the use of multiple scattered waves to study dynamics and mechanical properties of materials, and applied these optical methods to measure the rheological properties of materials in what is now called microrheology.

Wednesday, July 10

12–1 p.m.

Grand Balloom AB



Commercial Workshops at Summer Meeting

Visiting these hosted Commercial Workshops during the 2024 AAPT Summer Meeting in the Westin Boston Waterfront Seaport District offers an invaluable opportunity for educators and physics enthusiasts to explore the latest advancements in teaching tools and resources. These workshops, hosted by leading industry vendors, provide hands-on demonstrations of innovative technologies and educational materials designed to enhance classroom experiences. Attendees can engage directly with product developers, gain insights into practical applications, and network with fellow professionals, all of which contribute to a richer understanding of contemporary physics education trends and methodologies.

Engaging Mechanics Demos Using the Smart Cart Demonstration Kit (PASCO scientific: Monday, 12:45–1:45 p.m., Galleria)

Engaging Mechanics Demos Using the Smart Cart Demonstration Kit – It can take years to develop demonstrations that are both engaging for students and beneficial to their understanding of physics. In this hands-on workshop, you'll learn how to demonstrate multiple mechanics concepts using the Smart Cart Demonstration Kit. We will showcase demos from the included Smart Cart Demonstration Manual, collect data using the award-winning Smart Cart and accessories, and share tips for making each demo a memorable success.

Adapting Traditional Science Labs to Modern Interactive Simulations With The Science Table by Anatomage (Anatomage: Tuesday, 12:45–1:45 p.m., Galleria)

The Science Table provides students with a library of virtual physics experiments to explore on an interactive 7-foot-long touch-screen table. This session will explore how these simulations can replace or supplement traditional lab experiences, providing students with new visual aids and pathways to learn physics concepts. During the session, we will review Newton's second law, double slit and orbital motion experiments through hands-on activities and demonstrate how these classical experiments have been adapted to a digital interface.

Newton's Second Law: Newton's Second Law experiment demonstrates the relationship between F=ma variables with an air glider and mass hanger setup.

Double Slit: The Double Slit experiment demonstrates the wave nature of light, with additional views that allow comparisons between the expected behavior of lasers, quantum particles, classical particles, and waves.

Orbital Motion: The Orbital Motion experiment simulates the dynamics within a 3-body or 2-body system, allowing students to manipulate variables such as mass and velocity to observe their impact on gravitational forces and motion

Advance Your Physics Lessons with Vernier Video Analysis® (Vernier Science Education: Tuesday, 1–11 a.m., Galleria)

Let's get started with Vernier Video Analysis! This easy-to-use video analysis software is the newer and more powerful. Join us to get hands-on experience using the app, as well as ideas for interactive physics lessons that use video clips to investigate projectile motion, circular motion, and human movement. You'll walk away with a free trial, plus tips for video setup, prepping clips for analysis, and collecting effective data.

Teaching Rotation with the Meter Stick Torque Set (PASCO scientific: Monday, 2–3 p.m., Galleria)

Teaching Rotation with the Meter Stick Torque Set – Hands-on exploration is key when it comes to teaching difficult concepts such as rotation. In this session, you'll learn how to use PASCO's award-winning Meter Stick Torque Set to investigate topics in rotation and the physical relationships that drive it. Join us for a guided introduction to this robust equipment set, where we'll cover how to perform labs about torque and Newton's second law for rotation and record live data using PASCO Wireless Sensors.

Can the Physics Community take the OpenStax books from Good to Great? Join a fireside chat followed by open-forum discussion with Expert TA (Expert TA: Monday, 10–11 a.m., Galleria)

How is collaboration done to improve Open Education Resources (OER)? Specifically, regarding the OpenStax textbooks, what would it take for physics educators to turn them into the best books available? The premise of affordable OERs is a wonderful idea, but we think what is missing is a centralized, organized approach. We would like to help with that part. We are contributing to this cause by providing a platform that allows faculty to effectively collaborate to make these resources better. We have also established editorial teams and have started a broad conversation with physics educators about joining an effort to take the OpenStax textbooks from good to great. Over 250 instructors have demonstrated the need for change in these textbooks by requesting access to our eBook Editor and dozens have submitted detailed reviews of the OpenStax texts. We want more people in this conversation, either to informally submit recommendations, or as paid members of one of our editorial teams. Join Expert TA CEO, Jeremy Morton, and Authoring and Editorial Team members Mike Tammaro, and David Marx, for an interactive discussion about this project and our efforts to change the way textbooks are published.

AAPT Exhibitors

Grand Ballroom Foyer: Sunday, 5–6:30 p.m.
Monday, 10 a.m.–5 p.m., Tuesday, 10 a.m.–4 p.m.

EXHIBITORS AT SUMMER MEETING – *Visit at the hours above*

https://www.aapt.org/Conferences/SM2024/Visit_These_Exhibitors.cfm

Visiting exhibitors at the 2024 AAPT Summer Meeting is an exciting opportunity to engage with the latest advancements in physics education and research. From cutting-edge laboratory equipment to innovative teaching tools, the exhibitors offer a diverse range of resources to enhance pedagogy and scholarship. Attendees can explore interactive demonstrations, network with industry professionals, and discover new solutions to challenges in physics education. Whether seeking inspiration for curriculum development or connecting with like-minded colleagues, visiting the following exhibitors promises to be a fruitful and enriching experience at the conference.

AFMWorkshop, Inc. - Experience the future of nanotechnology education with AFMWorkshop, Inc. Their cutting-edge Atomic Force Microscopes revolutionize the way we learn about the nanoscale world.

Anatomage, Inc. - Step into the world of virtual reality with Antomage, Inc. They pioneered the use of VR in physics education, providing immersive and interactive learning experiences.

Arbor Sientific - A trusted supplier of educational science tools and resources, specializing in hands-on learning products for physics and physical science classrooms. They offer a wide range of innovative and engaging equipment designed to make teaching and learning science both effective and enjoyable. With a commitment to quality and educational excellence, Arbor Scientific supports teachers and students in exploring the wonders of science.

ARRL Teachers Institiute - An educational program designed to enhance STEM curricula through the integration of wireless technology and amateur radio. By providing teachers with hands-on training and resources, the ARRL aims to inspire students and promote interest in science, technology, engineering, and mathematics. This initiative empowers educators to bring innovative and interactive learning experiences into their classrooms.

American Physical Society - Engage with the largest professional body of physicists worldwide. Discover their latest research findings and educational resources pushing the boundaries of physics.

Austin Education LLC - Get hands-on with Austin Education LLC's innovative teaching tools. Their products are designed to make physics education interactive, fun, and engaging.

CREOL, The College of Optics and Photonics/University of Central Florida - Explore the fascinating world of light with CREOL. They are at the forefront of research and education in optics and photonics.

Expert TA - See how online homework, quizzes, and exams can be administered in a user-friendly environment. The platform offers an extensive problem library of textbook independent questions with dynamic feedback for unique student mistakes. They also offer instructors the ability to customize the OpenStax texts within an eBook editor, allowing them to embed videos & simulations, change content such as wording and images, and adjust the sequence of the texts.

Klinger Educational Products Corp. - Discover Klinger's latest advancements in scientific and laboratory equipment. Their products are designed to facilitate the most complex physics experiments and research.

KUDU - Experience KUDU's innovative approach to physics education, combining interactive software with real-world experiments.

M.I.T. Physics - A leading department within the Massachusetts Institute of Technology, renowned for its cutting-edge research and excellence in teaching. The department is dedicated to advancing the understanding of fundamental physics through groundbreaking experiments and theoretical work. MIT Physics fosters a collaborative environment that cultivates innovation and educates future leaders in the field.

Pasco scientific - Explore Pasco's wide range of physics education resources. Their products inspire students and spark curiosity about the physical world.

Quantum Experience Ltd. - Dive into the quantum world with Quantum Experience Ltd. Their interactive demonstrations bring quantum physics to life in fascinating ways.

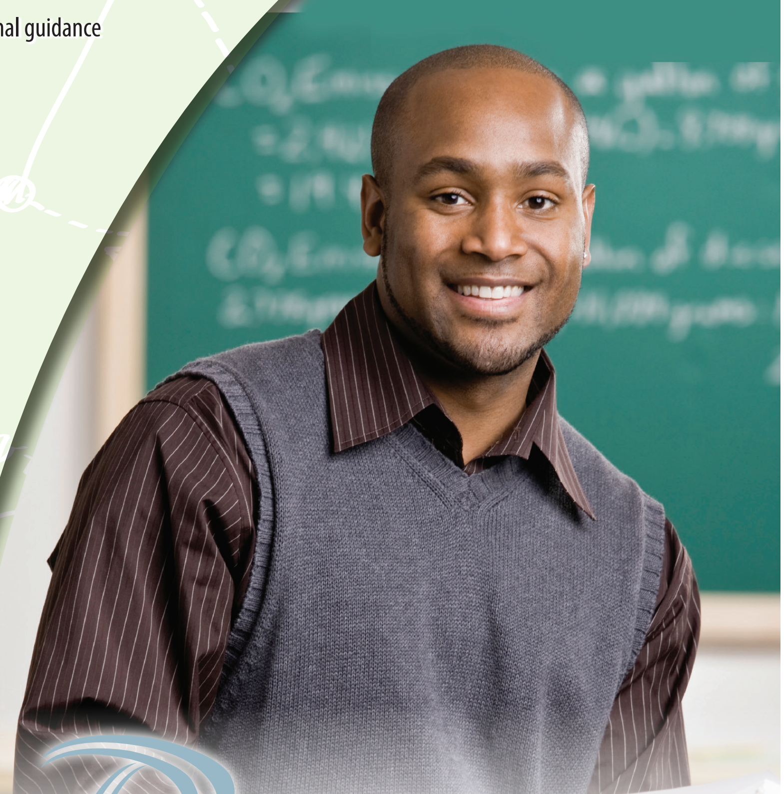
Society of Physics Students - A professional association designed for students with an interest in physics. SPS promotes the development of its members through professional networking, research opportunities, and educational resources. It fosters a supportive community that encourages collaboration, innovation, and the pursuit of careers in physics and related fields.

Thorlabs - Engage with Thor Labs to see how their cutting-edge equipment and tools push the boundaries of physics. Looking for engaging and impactful resources to share with your colleagues and students? The Mobile Lab is a fully equipped photonics laboratory, home to over 3000 lbs of cutting-edge photonics equipment and demonstrations, accommodating up to 15 people. Our well-trained presenters ensure a safe learning environment, with lasers kept below 2 mW for most demonstrations and laser safety equipment provided for class 3 lasers.

US Large Hadron Collider Users Association - Join the US Large Hadron Collider Users Association to learn about their latest research findings and the exciting opportunities in the world of particle physics.

Vernier Science Education - A leading provider of innovative science education solutions, offering a wide range of data-collection technology and software for classrooms. Dedicated to enhancing STEM learning, Vernier provides educators with tools to engage students in hands-on scientific exploration and experimentation. With a strong commitment to advancing science education, Vernier supports teachers and students from elementary to college levels.

Prepare to be inspired, educated, and enthralled. We can't wait to see you at the 2024 AAPT Summer Meeting!



Workshops at Summer Meeting

Saturday, July 6, 2024

AP Physics Course Revisions for Fall 2024

Date: July 6 Time: 8:00 AM to Noon Commonwealth A Organizer(s): Kathleen Harper, Amy Johnson, John Pinnizotto, Jesse Miner

The 2024-25 school year will introduce a new, common, exam format for all AP physics courses, as well as some curricular modifications for each course. This includes a smaller set of science practices, consistent across all four courses. The workshop will familiarize teachers with the new curricula. It will take a deep dive into the key features and major differences between the new curriculum and its predecessor, focusing on science practices. Attendees will develop skills to adapt and implement the new curriculum in their classrooms. The revised exams will be reviewed and participants will work through case studies with sample questions tied to each science practice. Strategies to prepare students will be discussed and modeled.

Bridging the Gap: Data Science Applications in Modern Physics Education

Date: July 6 Time: 8:00 AM to Noon Webster Organizer(s): Alexis Knaub, Casey Berger, Ashley Dale, Radha Mastandrea, Mohammad Soltanieh-ha, William Ratcliff

This workshop will introduce participants to incorporating data science into the undergraduate physics curriculum. The materials were developed by a dedicated team of postdocs and PhD students who were fellows of the Data Science Education Community of Practice (DSECOP). We will do a hands-on walk-through of getting started with Cloud-based tools such as Google Colab before leading an interactive session on two lessons that can be used in different physics courses. One lesson will focus on how Monte Carlo methods in physics naturally extend to machine learning algorithms such as deep neural networks using the Ising model as an example. The other lesson will provide an introduction to histograms as a tool for exploratory and more in-depth data analysis, providing instruction on both constructing and analyzing histograms. We will also have faculty who have taught using these tools provide their insights on what's required for a successful experience. All of the materials are freely available. The modules are hosted at:https://github.com/GDS-Education-Community-of-Practice/DSECOP Please bring a laptop and make sure you have a Google account. This workshop is targeted toward those who have some knowledge of Python. The material was designed with postsecondary education physics faculty in mind. No prior experience in data science is required.

Building Thinking Classrooms

Date: July 6 Time: 8:00 AM to Noon Stone Organizer(s): Earl Legleiter

Sense making in a science class has the expectation that students think. This workshop will engage participants in a thinking classroom in which thinking to make sense of a phenomena is the norm, and students are discouraged from slacking, stalling, mimicking, and faking their way through the physics content. The goal of a thinking classroom is to build engaged students that are willing to think about any task.

Demos @ MIT

Date: July 6 Time: 8:00 AM to Noon MIT Room 6-120 Organizer(s): Joshua Wolfe, Caleb Bonyun, Christopher Miller, Rosie Anderson

The purpose of this workshop is to provide an example of how a larger demonstration group operates and how we have integrated ourselves into flipped classrooms beyond providing demonstration services. The workshop will include a tour of all of our classrooms, workshops, storage, and lab spaces necessary for our education mission; a presentation on the structure of PIRL (Physics Instructional Resources Lab), how it fits within the Physics Department; and how we use demonstrations in the flipped classroom model; followed by a physics demonstration show exhibiting many of the historical pieces that currently reside within PIRL's demonstration collection, including Robert J. Van de Graaff's prototype Van de Graaff, and a Marconi coil of the same make as was on the Titanic. There will be a decent amount of travel between rooms so bring comfortable shoes. All spaces will be accessible via elevator for people with mobility disabilities.

Exploring Physics through the Lens of Systems

Date: July 6 Time: 8:00 AM to Noon Hancock Organizer(s): Michael Lerner, Kelly O'Shea

In physics, we often just focus on the forces or motion of one object that we treat as a dot. But we can also make that dot represent what looks like multiple objects at first glance. Learning to think in terms of multiple systems can help students see problems from multiple perspectives or at multiple scales, allowing them to find new insights or simplify their work. In this workshop, we will explore the concept of systems and system models. This NGSS crosscutting concept can be integrated into the four fundamental models of introductory physics (kinematics, forces, energy, and momentum) with small changes or additions that help students think in terms of systems. We will explore using systems thinking in the four models through labs, problems, and discussions. Thinking in terms of systems will even allow us to naturally develop the idea of center of mass and explore interdisciplinary concepts like the sociopolitical context of a nuclear power plant. Although we hope that this workshop will be interesting to a wide audience, our target audience is high school teachers.

Intermediate and Advanced Labs workshop

Date: July 6 Time: 8:00 AM to Noon Commonwealth C Organizer(s): L Dana, Nathan Tompkins, Nathan Powers

This workshop is appropriate for college and university instructional laboratory developers. At each of five stations, presenters will demonstrate an approach to an intermediate or advanced laboratory exercise. Each presenter will show and discuss the apparatus and techniques used. Attendees will cycle through the stations and have an opportunity to use each apparatus. Documentation will be provided for each experiment, with sample data, equipment lists, and construction or purchase information.

Writing and Evaluating Curricular Materials for the IPLS Portal

Date: July 6 Time: 8:00 AM to Noon Otis Organizer(s): Juan Burciaga

The Living Physics Portal (LPP) is an effort by the physics and biology faculty and PER/BER researchers to design, develop, and disseminate new curricular materials for the courses in introductory physics for the life sciences. The first part of the workshop will focus on finding, adapting, and using curricular resources on the LPP. Several sample key resources will be identified and studied. The last part of the workshop is designed to introduce the concepts, practices, and standards of educational scholarship. Faculty who adopt curricular resources from the LPP or other sources will therefore be better able to offer insightful critiques to the developers of the curricular resources. Interested faculty may also learn how to develop curricular materials for their own classrooms for use by the LPP community. Attendees will find having a laptop useful but not required.

Authentic Data-based Astronomy Research with JS9

Date: July 6 Time: 1:00 PM to 5:00 PM Stone Organizer(s): Pamela Perry

Cost of workshop will be refunded for attendees. Js9 web-based software allows you to retrieve, display, and analyze data from astronomical archives. This access to real data from observatories in all bands of the electromagnetic spectrum together with js9 analysis tools such as light curves, energy spectra, and more allow one to pursue their own research projects. In this workshop, you will be introduced to the js9 interface and toolbox, how to find FITS files and upload them, and ideas for various research projects such as on colliding galaxies, type 1a vs type 2 supernovae, expansion rates of supernova remnants, and possible evidence for dark matter. We will also discuss how existing scientific papers can be "backwards engineered" to construct introductory activities to familiarize users with js9 before a research project. The material in this workshop is suitable for use in amateur astronomy clubs, Science Olympiad groups, classrooms, and labs. Please bring a laptop.

Integration of Computation into Lab Courses

Date: July 6 Time: 1:00 PM to 5:00 PM Otis Organizer(s): Steve Spicklemire

Participants will learn a number of ways to incorporate computation in laboratory activities and experiments. Python will be used, along with Jupyter notebooks, and a number of python extensions often used in data science applications. Activities will also involve interfacing with experiments and collecting data directly. Please bring a laptop computer.

Quantum Computing: What's the Buzz?

Date: July 6 Time: 1:00 PM to 5:00 PM Webster Organizer(s): Beth Thacker, Tunde Kushimo

Are you interesting in learning more about Quantum Computing? Have you been asked to teach it or introduce some of the concepts into courses you are already teaching? What's the state of the field anyway? Do you just want to be more informed about this fascinating, relatively new field? Should it be taught in Physics or Computer Science or Chemistry or Math or all of them!? If you find yourself interested in these questions, this workshop is for you. We will give an overview of the present state of the field, present an introduction to Quantum Computing, including discussion of our experiences learning the topics and teaching them, course coverage, format and learning materials, research we have done on student strengths and difficulties in learning quantum computing topics, and the development of evidence-based materials to teach the course. We will share information on freely available online resources, our own evidence-based materials, and possible texts. We will focus on an undergraduate course, but it will be relevant for classes above and below that level, too. Bring a wi-fi enabled laptop.

Sunday, July 7, 2024

Developing Strategies for Accessible and Inclusive Group Work

Date: July 7 Time: 8:00 AM to 5:00 PM Commonwealth A Organizer(s): Daryl McPadden, Erin Scanlon, Matt Guthrie, Xian Wu

The purpose of this workshop is to collectively develop strategies for accessible and inclusive group work. Through an extensive literature review, we have developed a guide of effective and inclusive group work strategies. Using this guide as a jumping off point, we will discuss and document accessible and inclusive practices to support disabled students in physics courses. This workshop is appropriate for high school teachers, postsecondary instructors, and students with an interest in teaching. Please bring your own computer to use during the workshop.

Learn Physics While Practicing Science: Introduction to ISLE

Date: July 7 Time: 8:00 AM to 5:00 PM MIT Room 4-349 Organizer(s): David Brookes, Yuhfen Lin, Yuehai Yang, Joshua Rutberg

Participants* will learn how to modify introductory physics courses at any level to help students develop a good conceptual foundation, apply this knowledge in problem solving, and engage them in science practices. The framework for these modifications is the Investigative Science Learning Environment (ISLE) approach. We provide tested curriculum materials including: (a) The second edition of College Physics Textbook by Etkina, Planinsic and Van Heuvelen, the Physics Active Learning Guide and the Instructor Guide; (b) a website with over 200 videotaped experiments and questions for use in the classroom, laboratories, and homework; (c) a set of innovative labs in which students design their own experiments, and (d) newly developed curriculum materials that implement the ISLE approach in both online and in-person settings. During the workshop the participants will learn how to use the materials in college and high school physics courses to help their students learn physics by practicing it. *Please bring your own laptop to the workshop if you own one. If you do not own a computer, you will be paired with somebody who does.

Demos @ Harvard

Date: July 7 Time: 8:00 AM to Noon Offsite Organizer(s): Daniel Davis, Allen Crockett, Daniel Rosenberg, Susan Schmidt, Wolfgang Rueckner

The Harvard Natural Sciences Lecture Demonstrations team welcomes participants to a half-day workshop including a tour of as many of our demonstration spaces (storage, fabrication, and preparation) as the untimely renovation of our Science Center and lecture halls will permit, as well as performing and answering questions on selected demonstrations spanning mechanics and fluids, electricity and magnetism, waves and optics, thermal, and modern physics. Each year we support roughly thirty courses reaching approximately two thousand students, who report demonstrations are among the most memorable and enjoyable aspects of their Harvard experience. In this workshop, we aim to provide the same to you. (https://sciencedemonstrations.fas.harvard.edu/)

Equity in STEM: Exploring the Underrepresentation Curriculum

Date: July 7 Time: 8:00 AM to Noon Marina II Organizer(s): Clausell Mathis, Abigail Daane, and Chris Gosling

The Underrepresentation Curriculum is a free, open, modular, teacher-created resource that supports high school and college science instructors in empowering students to examine issues of equity, identity, and justice in society and in STEM. This workshop will introduce the curriculum by engaging participants themselves in the learning activities (e.g., discussing the role of objectivity and subjectivity in science and analyzing data about disparities in representations of certain groups of people). The workshop will familiarize participants with the support materials available and make space for exploration. Finally, participants will have the opportunity to discuss how the curriculum can be implemented in their classrooms, and collaborate with other instructors to create viable actions beyond the workshop.

Incorporating Computational Physics in the Undergraduate Curriculum

Date: July 7 Time: 8:00 AM to Noon Webster Organizer(s): Andy Garvin, Gautam Vemuri,

This interactive workshop welcomes all physics instructors from high schools (AP), two-year colleges, 4-year colleges, and universities who are interested in including a computational component in their courses. The workshop will offer multiple resources attendees can use in the classroom including instructional materials and assignments. We will also include an introduction to the resources on the PICUP web site (Partnership for Integration of Computation into Undergraduate Physics) https://www.compadre.org/PICUP/, and assessment tools. Attendees will also benefit from getting to know others who are interested in computing in the physics curriculum, and network with others with similar interests. The workshop will include hands-on time, so please bring a laptop. No prior programming experience is needed. We will present materials and provide resources in multiple formats including excel spreadsheets. This workshop is supported by the NSF, grant DUE-2021209.

Maximizing Learning and Engagement with Demonstrations

Date: July 7 Time: 8:00 AM to Noon Marina I Organizer(s): Patrick Morgan

In this workshop we will start with a discussion and questions on ways we have used demonstrations in the past. We'll work together to make a list of what has and has not worked regarding how demonstrations were used. In particular, we will focus on the format and methods of presentation, rather than the specific equipment. From there, we'll learn about the Demonstration Framework model, and how to use it for demonstration development. We will then break into pairs, and each attendee will use the model to develop their own hypothetical demos. In the end, everyone who attends will get their own printed copy of the framework to take home so they may continue to use it.

LHC Physics in the Classroom

Date: July 7 Time: 8:00 AM to Noon Hancock Organizer(s): Shane Wood

Students who complete an introductory physics course may be under the impression that physics somehow "stopped" in the late 19th or early 20th century. Of course this idea could not be further from the truth, as physicists today continue to work on addressing an ever-growing list of unsolved questions: Where has all the antimatter gone? What is dark matter? What is dark energy? (What questions have we not thought of yet?) Physicists from all over the world work to address these and many other questions at the Large Hadron Collider (LHC) at CERN, on the border of Switzerland and France. This workshop will focus on how teachers can tap into the excitement of LHC physics to both motivate students and provide a contemporary context for them to engage with topics and practices covered in introductory physics courses, including (but not limited to) conservation laws, data collection, organization, and analysis, and making claims based on evidence. Participants in this workshop will alternate between "student mode" and "teacher mode", will analyze authentic LHC data, and will get a chance to work through some activities from QuarkNet's Data Activities Portfolio. The workshop will conclude with a discussion on classroom implementation. Some of the activities will be computer-based, so please bring along a laptop! This workshop is supported by the NSF-funded QuarkNet program, https://quarknet.org, and OPTYCs, https://optycs.aapt.org.

Professional Development for Emerging Education Researchers (PEER)

Date: July 7 Time: 8:00 AM to Noon Commonwealth C Organizer(s): Scott Franklin, Mary Bridget Kustusch, Eleanor Sayre

PEER is designed for emerging education researchers interested in expanding theoretical or methodological expertise. Through peer and near-peer exchange, this PEER workshop involves hands-on activities to increase participants' capacity for Discipline-based Education Research. Topics include research design, choosing appropriate theoretical frameworks, and matching one's research questions to accessible data. A hallmark of PEER workshops is their responsiveness to participant interests, and activities center around advancing each individual's specific research project.

Quantum Journey in a Box

Date: July 7 Time: 8:00 AM to Noon Revere Organizer(s): Jean-Francois Van Huele, Charlotte Whiteside

In this workshop we will introduce and play games that we have developed to motivate K12 students to learn concepts from quantum information science: quantum key distribution, quantum cloning, and quantum teleportation. No prior quantum knowledge needed.

Biomedically Relevant Physics with Phones!

Date: July 7 Time: 1:00 PM to 5:00 PM Webster Organizer(s): Scott Franklin, Nancy Donaldson, Mayuri Gilhooly

How can your smartphone help you investigate blood flow across your heart valves? The normal forces that act on you during a walking gait? A running gait? Participants in this workshop will use their smartphones to experience hands-on, inquiry-based biomedical investigations designed to engage physics students interested in health and life sciences. The workshop curriculum will use the sensors already embedded in every smartphone, thus increasing usability and making it possible for every student in your classroom (in-person or remote) to conduct the experiments. Using state-of-the-art medical applications, participants will conduct experiments using the accelerometer, gyroscope and image sensors on your phone to characterize the biomechanical motion of your gait, cardiac cycle including aortic and mitral value opening and closing, the periodic blood flow in your finger during systole and diastole, and the physiological tremors of your hand. Editable, active-learning biomedical physics curriculum using the smartphone as a sensor will be shared allowing faculty to implement the smartphone as an investigative tool in your "Introductory Physics for the Life Science and Beyond" classrooms. Participants should bring their own smartphone to this workshop and a computer loaded with their favorite spreadsheet software to process data that will be collected during the workshop.

Reasoning with Multiple Representations in AP Physics (and Beyond)

Date: July 7 Time: 1:00 PM to 5:00 PM Commonwealth A Organizer(s): Kathleen Harper, Jeff Funkhouser, Rebecca Howell, Amy Johnson, John Pinnizotto, Jesse Miner

The 2024-25 school year will introduce revamped AP physics exams in all courses. This workshop will briefly share highlights of the exam redesign, one of which is reasoning with multiple representations (words, diagrams, equations, graphs, etc.). The bulk of the workshop will be participants working through and discussing a variety of problem solving activities that incorporate multiple representations. While these curricular tools will be presented in the context of AP courses, they are impactful in any physics course.

200+ Physics Simulations to Inspire Classroom Engagement

Date: July 7 Time: 1:00 PM to 5:00 PM Stone Organizer(s): Andrew Duffy, Emily Allen, Manher Jariwala

In this workshop, participants will explore more than 200 physics simulations, learn about research-based best practices for their use, and create activities for their own classrooms. The VIPER physics simulations (http://physics.bu.edu/~duffy/VIPER/) and best practices shared in this workshop are for introductory physics and astronomy at both the college and high school levels. The majority of the time spent in this workshop will be in creating new activities, providing opportunities for participants to share in small groups, elicit feedback from each other, and work through a multi-step design process. Existing activities created by our Boston University PER group and others will be shared as examples and models for the developed work. As the goal of this workshop is for participants to walk away with completed activities for their own classroom, we ask that everyone please bring a laptop to the workshop. The Visualizations in Physics Education Research (VIPER) project is supported by NSF DUE-2120980 and DUE-1712159.

Computer Science Integration in HS Physics and Physical Science

Date: July 7 Time: 1:00 PM to 5:00 PM Hancock Organizer(s): Chris Orban

Ever wondered how to integrate a little bit of coding or data science into a high school physics or physical science class without overwhelming your students or taking up lots of class time? This hands-on workshop will provide an overview of simple, conceptually-motivated "STEMcoding" exercises where students construct PhET-like games like asteroids and angry birds using an in-browser editor that works great on chromebooks or whatever devices you have. We will also provide a tutorial of the STEMcoding Object Tracker which is a browser-based program that can track the motion of brightly colored objects moving against a solid colored background. These activities are part of a much wider curriculum that is highlighted on the STEMcoding YouTube channel (http://YouTube.com/c/STEMcoding). The STEMcoding project is led by Prof. Chris Orban from Ohio State Physics. PLEASE BRING A LAPTOP, chromebook or a tablet with a physical keyboard.

Dreaming of Liberatory Futures in Physics Education

Date: July 7 Time: 1:00 PM to 5:00 PM Commonwealth B Organizer(s): Amy Robertson, Lauren Bauman, Trà Huỳnh, W. Tali Harrison, Vero Vélez

Physics has been and continues to be a site of racial oppression, as evidenced by both the stories of harm voiced by People of Color in the discipline and by the large-scale patterns in outcomes for People of Color in the field. A critical lens calls us to both acknowledge and seek to dismantle the impacts of white supremacy in physics and to lean into a liberatory imagination, envisioning and then working to co-create a future that centers collective thriving. As a conceptual framework and methodological approach, critical race spatial analysis (CRSA) provides such a lens to help identify spatial dimensions of injustice in physics teaching and learning, while simultaneously curating "counter-spaces" that dream imagined futures to design racially just classrooms. As part of a NSF-funded project, an interdisciplinary team that includes physics undergraduate students are collaborating to articulate the possibility of a new spatial imaginary in physics, guided by the tenets of CRSA. For this workshop, we will share both the process and products of this dreaming process, including visualizations of liberatory physics classrooms. We will invite participants to co-dream with us about liberatory physics education through a series of discussions, art-making, and curricular planning centered around three questions: 1) How can art be employed to examine oppression in classrooms and other learning spaces and used to design a physics community in which everyone gets what they need and deserve? 2) What kinds of collectives and strategies could we curate or join to make a vision of a liberatory physics education "real"? and 3) How might we build from this workshop, as physics instructors, to transform physics classrooms going forward?

Dual Process Theories to Interpret Students' Physics Reasoning

Date: July 7 Time: 1:00 PM to 5:00 PM Commonwealth C Organizer(s): Andrew Boudreaux, Beth Lindsey, MacKenzie Stetzer, Mila Kryjevskaia, Paula Heron

We have been investigating the relationships among students' intuition, reasoning, and conceptual understanding in physics. A major part of this project has been the development of assessment tasks and methods for disentangling conceptual understanding and reasoning. We have drawn on dual-process theories of reasoning from cognitive science in the interpretation of student learning data and the development of instructional interventions to improve student reasoning. In this workshop, participants will engage with these issues by examining written student responses and viewing and discussing video. We will present curricular interventions developed in alignment with dual-process theories and will describe a framework that can be used for the development of additional interventions.

Fun, Engaging, Effective, Intro Labs and Demos (plus Virtual Options)

Date: July 7 Time: 1:00 PM to 5:00 PM Otis Organizer(s): David Sokoloff, Ronald K. Thornton

Participants in this workshop will have hands-on experience with research-validated active learning activities for the introductory laboratory—including RealTime Physics (RTP) labs using computer-based tools and video analysis—that have been used effectively in university, college and high school physics courses. They will also experience Interactive Lecture Demonstrations (ILDs)—a strategy for making lectures more active learning environments. These active learning approaches are fun, engaging and validated by physics education research (PER). Research results demonstrating the effectiveness of RTP and ILDs will be presented. Emphasis will be on activities in mechanics, electricity and magnetism and optics. Distance learning options for lab and lecture will also be included. The following will be distributed: Modules from the Third Edition of RTP, the ILD book and free access to virtual materials for lab and lecture. Participants should bring their laptop (with USB-A or USB-C connection). They will be given a link to download Vernier Graphical Analysis and Video Analysis to use in the workshop along with a free trial period.

Introductory Labs to Promote Scientific Reasoning

Date: July 7 Time: 1:00 PM to 5:00 PM Revere Organizer(s): Krista Wood, Kathleen Koenig, Lei Bao

Scientific reasoning and decision-making abilities are highly sought outcomes of modern education. We have developed and evaluated a complete inquiry-based lab curriculum that explicitly promotes these abilities by engaging students in activities that include designing and conducting controlled experiments, making appropriate decisions, conducting data analysis, and interpreting and synthesizing results to construct meaningful evidence-based claims. The curriculum aligns with the AAPT Lab Guidelines and cultivates an inclusive culture to support a diverse population. During the workshop, participants will work through several lab activities to learn about the underlying curricular framework, which involves operationally defined sub-skills: including abilities for controlling variables in multi-variable contexts, data analytics, and causal reasoning. Participants will learn how assessments can be used to measure important skills-based outcomes, and our own results will be shared. Participants will be provided access to all lab materials (both in-person and online versions) and assessments, as well as learn how to modify their existing in-person or online labs, if preferred.

TEAM UP Together & Transfer Students: Supporting student transfer between two- and four-year institutions

Date: July 7 Time: 1:00 PM to 5:00 PM Alcott or Harbor Ballroom II Organizer(s): Arlene Modeste Knowles, Joe Heafner, Mel Sabella, Anthony Escuardo, Arlisa Richardson

For students transferring from two-year to four-year institutions, the transition itself is known to have multiple challenges. Given that a larger proportion of minoritized students, especially Black and African American, begin their physics degrees at two-year colleges, building better bridges across these institutions can provide necessary support for student success. In this workshop, we explore the findings from the TEAM-UP report, and work collaboratively to strategize ways to make the transfer process seamless. These plans will help all transfer students succeed, and have the potential to help all students by reducing barriers to success. This workshop is sponsored by the TEAM-UP Together Program and The Organization for Physics at Two-Year Colleges (NSF grant #2212807).

TEAL Blended Learning Workshop

Date: July 7 Time: 1:00 PM - 5:00 PM MIT Room 32-082 Organizer(s): Sean Robinson, Peter Dourmashkin, Michelle Tomasik, Mohamed Abdelhafez, Shams El-Adawy

Technology Enabled Active Learning (TEAL) is a twenty-three year ongoing educational experiment at MIT in developing a flipped active learning model for two introductory physics courses, Physics I Newtonian Mechanics (8.01) and Physics II Electricity and Magnetism (8.02). The workshop will be held in the TEAL classroom at MIT. It will include a description of the pedagogical model and an example lesson illustrating how Faraday's Law is taught in the TEAL style. Participants should bring their laptops.

OPTYCS: TEAM UP Together &B7 Transfer Students: Supporting student transfer between two- and four-year institutions

Date: July 7 Time: 1:00 PM - 5:00 PM Alcott Organizer(s): Arlene Modeste Knowles, Joe Heafner, Mel Sabella, Anthony Escuardo, Arlisa Richardson

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POSTER SESSION I:
Location: Pavilion **Sponsor:** AAPT
Time: 5:30–6:30 p.m. **Date:** Sunday, July 7

Astro (Astronomy and Astrophysics) Posters I

(SUN-POS-C-301) I Poster Presentation Traditional I First Results from a New Student-Operated Radio Astrophysics Facility at MIT

Presenting Author: Sean Robinson, MIT
Additional Author | Daniel Sheen, MIT
Additional Author | Oris Salviano Neto, MIT
Additional Author | Aaron Pilarcik, MIT

We will discuss the recent history of how a defunct 6-meter radio dish was rehabilitated by students in our university's amateur radio society into a modern, functional facility capable of impressive astrophysical measurements (as well as other radio communication tasks), now made available for educational use by students in our advanced physics laboratory course. Data and results from the first student projects at this new facility will be presented.

(SUN-POS-C-303) I Poster Presentation Traditional I NASA's Universe of Learning Informal STEM Network

Presenting Author: Donna Young, NASA/UoL/NSO
Additional Author | Pamela Perry, Lewiston High School

There are opportunities to become involved with the NSO NASA Universe of Learning Astrophysics STEM Learning & Literacy Network. NSO is a national nonprofit organization dedicated to improving the quality of K12 science education, increasing interest in science for all students, creating a STEM literate workforce, and providing recognition for outstanding achievement by students and educators. These goals are achieved by participating in events at invitational, regional, state and national tournaments, and incorporating Science Olympiad events into classroom curricula. Events address NGSS scientific practices, crosscutting concepts and core disciplinary ideas from every scientific discipline, including astronomy. One of the resources developed for the programisJS9 –image analysis software used by the Chandra scientists. The NSO is one of many partnerships organized by the UoL Program Managers to increase scientific literacy about the universe. The partners provide scientific talks, activities and investigations, webinars, and several online interactive tools to engage students, educators, and the general public in understanding how the universe works.

(SUN-POS-C-305) I Poster Presentation Traditional I Physical Model of Binary Star Systems for Student Training and Classroom Activities

Presenting Author: Sarah McGregor, Keene State College
Co-presenting Author | Keith Goodale, Keene State College

A binary system consists of two gravitationally bound stars orbiting a common center of mass. For data collected intermittently, researchers employ phase folding to construct the light curve, a concept often perplexing to students. To address this, we construct a physical model of a binary star system using light bulbs and a turntable. To simulate real world data collection from our simulated binary star setup, we use a programmable shutter and light sensor. This data is the foundation for an innovative training method for students to better understand the technique of phase folding and how it relates to the binary star system in question. Additionally, this setup, the training data, and process can be implemented as the basis for astronomical classroom activities. This poster covers the formulation of the physical model, data collection, training approach, and demonstrates possible activities for integration in astronomy coursework.

(SUN-POS-C-307) I Poster Presentation Traditional I Developing Children's Interest & Knowledge in Eclipses as "Chasers" and Peer-Experts

Presenting Author: Nicole Glen, Bridgewater State University
Additional Author | Leslie Kola, RaynWater STEAM
Co-presenting Author | Shawn O'Neill, Bridgewater State University

This poster will explain the multi-experience programming that STEM educators provided across two towns who were experiencing the partial eclipse on April 8, 2024. While much attention is paid to educating those in the path of totality about solar eclipses, we provided multiple educational experiences both in and out of schools so that local children could understand the partial eclipse and be excited to view it. With funding from a state grant, we provided the following solar eclipse learning experiences before and during the eclipse: an introductory lesson on the basic mechanics and objects of a solar eclipse to kindergarten through fifth grade students; bringing high school students to the elementary schools to read high-quality children's trade books about the eclipse and show how to use solar eclipse glasses; instituting a three-part out-of-school solar eclipse "chaser" program for children in grades three through eight to provide more in-depth learning than the in-school sessions; creation of posters and videos in "mythbuster" style by middle school students that were sent to the elementary schools; offering a district-wide, multi-town solar eclipse watch party with learning experiences during it. Assessment data from the solar eclipse "chaser" program and poster/video mythbusters will be included in the poster.

(SUN-POS-C-309) I Poster Presentation Traditional I Astronomy in Rural High Schools: Insights from Illinois Science Teachers

Presenting Author: Spencer Wilken, University of Illinois Urbana-Champaign
Additional Author | Leslie Looney, University of Illinois Urbana-Champaign

We present findings from a preliminary study on the current landscape of astronomy curricula in rural high schools across Illinois and propose a Large Language Model astronomy assistant for instructors. Through nearly 40 interviews with science teachers, we explore how space-related subjects are integrated into physics, chemistry, and biology classrooms. We observed cases of the complete removal of astronomy mentions beyond Earth-based systems, but, on the other hand, unique instances where standalone astronomy courses are actively embraced as introductory science for freshmen and sophomores. Due to the commonly 'self-determined' nature of rural curriculum, an instructor's exposure to astronomy prior to teaching (e.g., while acquiring college degrees, certifications, and continued education) appears to play a major role defining its presence in rural classrooms. We will compare these findings to trends observed in urban high schools, gaining insight into similarities and disparities between these educational environments.

Beyond Intro Posters I

SUN-POS-G-601) | Poster Presentation Traditional | Is Energy Doubled in Constructive Interference?

Presenting Author: Guofen Yu, The University of Findlay

According to classical wave theory, the energy of a pulse or wave is proportional to the square of its amplitude. When two pulses or waves of equal amplitude, A, propagate towards each other, they can exhibit constructive interference, resulting in an amplitude of 2A, or destructive interference, resulting in zero amplitude. This implies violations of energy conservation, with constructive interference seemingly doubling the energy and destructive interference seemingly annihilating it. This apparent contradiction is addressed by analyzing the velocities and energies involved in the superposition of two pulses on a string and waves in two dimensions, respectively. Through mathematical analysis, it is demonstrated that the conservation of energy remains intact even in the presence of interference.

(SUN-POS-G-603) | Poster Presentation Traditional | Modeling Radiation Trapping in Alkali Vapors

Presenting Author: Steve Spicklemire, University of Indianapolis

Co-presenting Author | Monte Anderson, United States Air Force Academy

Co-presenting Author | Anita Dunsmore, United States Air Force Academy

Co-presenting Author | Brian Patterson, United States Air Force Academy

We discuss an undergraduate capstone project involving the visualization of Monte Carlo simulations of radiation trapping in alkali metal vapors in various buffer gases and comparison to experimental data. Radiation trapping is the confinement of light in atomic vapors by successive absorption and reemission of photons. If the vapor is sufficiently dense, the apparent lifetime of the atomic excited state, as observed in the fluorescence decay, may be significantly longer than the natural lifetime. The calculations modeled and visualized the random walk of photons in potassium vapor with a helium buffer gas in a small, temperature-controlled cell, from initial absorption using a broadband laser source to eventual escape and detection. The calculated effect on the measured lifetime was compared to the results of an experiment having the same geometry and utilizing a Ti:sapphire pulsed laser for excitation. This project has allowed undergraduates to meaningfully integrate numerical and experimental techniques and explore various modes of data visualization.

(SUN-POS-G-605) | Poster Presentation Traditional | Visualizing the Ideal Gas with Differential Forms on a PV-diagram

Presenting Author: Roberto Salgado, St Catherine University

We visualize the ideal gas using dual vector fields (differential one-forms) on a pressure-vs-volume (PV) diagram. (Think of a set of equipotentials in the neighborhood of a point.) In particular, we visualize the inexact differential forms for work W and heat Q (which result in path-dependent quantities for processes) and the exact differential form for internal energy U (which results in a path-independent quantity for processes). Our visualization describes the distinction between exact and inexact differential forms. We suggest a graphical method to compute the work, heat, and change in internal energy for an arbitrary process on a PV diagram.

(SUN-POS-G-607) | Poster Presentation Traditional | Ungrading a Modern Physics Course

Presenting Author: Edwin Greco, Georgia Institute of Technology

In this poster we discuss efforts to ungrade a modern physics course in an effort to improve intrinsic motivation and learning outcomes. The course was composed primarily of physics majors and structured around three one-on-one conferences with students spread across the semester. During these conferences students reported their motivation for succeeding in the course, their learning goals, proposed activities to support these goals, and developed an assessment plan to determine their grade in the course. Throughout the course, the instructor provided formative and summative feedback as well as a variety of active learning activities. In place of a final exam, students showcase their work during a poster session. We will discuss grade distributions, student course evaluations, and results from the Quantum Mechanical Concept Inventory.

(SUN-POS-G-609) | Poster Presentation Traditional | From Spins to Wave Functions: A Discrete Bridge

Presenting Author: Artur Tsobanjan

Additional Author | Gerardo Giordano, King's College, Wilkes-Barre

The popular "spins first" approach to teaching undergraduate quantum mechanics allows the instructor to concentrate on the conceptual difficulties of quantum physics before treating it in its full technical complexity. Nevertheless, this approach still requires students to make a challenging and rather abrupt learning leap when instruction shifts from spin systems to quantum particles. We present an approximately week-long "intervention" consisting of classroom activities and assignments that we have inserted into our "spins first" quantum mechanics course at the point of transition from spins to particles. Specifically, we use discrete-space toy models to introduce important features of wave functions, while remaining solidly grounded in the intuition about quantum mechanics of discrete systems that our students have developed by this stage in the course.

(SUN-POS-G-611) | Poster Presentation Traditional | Quantum-CT: Developing a Quantum Workforce through Partnership and Collaboration

Presenting Author: Diego Valente, University of Connecticut

Co-presenting Author | Christine Broadbridge, Southern Connecticut State University and Yale University

Additional Author | Florian Carle, Yale University

Quantum-CT is a large-scale workforce development enterprise seeking to generate a pipeline of knowledgeable, skilled, and diverse individuals who can fulfill roles across a broad spectrum in the quantum industry, spanning lower and higher-level technical positions, research and development, as well as roles in non-technical adjacent fields, such as business and entrepreneurship, patent and legal, and policy making. Quantum-CT's vision is built from collaboration and partnership, with quantum education and training resources being developed and disseminated state and region wide across multiple institutions to educate a generation of quantum literate students and professionals that will form the foundation of a future quantum workforce. Such resources will include courses and educational modules developed for audiences from K-12 to graduate level, degree and non-degree conferring certificate-level training, 2-year, 4-year, and graduate level advanced degrees. Practical training in the form of internship programs will provide a vital direct link between education hubs and industry. Programs to support this flow of information and innovation will engage state, local and community leaders, policy makers and stakeholders. We present an overview of the Quantum-CT initiative in the state of Connecticut, along with some of the specific efforts currently underway to help bring this vision to fruition.

(SUN-POS-G-613) | Poster Presentation Traditional | Transitioning Paper Tutorials to an Online Platform with Interactive Feedback

Presenting Author: Jonan-Rohi Plueger, University of Colorado, Boulder

Additional Author | Steven J Pollock, University of Colorado, Boulder

Additional Author | Gina Passante, California State University - Fullerton

Additional Author | Bethany R Wilcox, University of Colorado, Boulder

The active-learning opportunities afforded by physics tutorials have been shown to effectively improve students' conceptual understanding in topics both from introductory physics and upper-division physics. Many professors, however, find it hard to justify using precious class time on a tutorial, or may not have the resources to run one. We have been developing a way to transfer paper tutorials online with interactive feedback/guidance messages, and in this talk I will discuss how we did this for quantum computing-related tutorials, how others might do the same, and what are the pros and cons of online tutorials.

(SUN-POS-G-615) | Poster Presentation Traditional | Quantum Curriculum Development at the University of Tennessee at Chattanoogag

Presenting Author: Tatiana Allen, University of Tennessee at Chattanooga

Additional Author | Christopher Cox, University of Tennessee at Chattanooga

Additional Author | Tian Li, University of Tennessee at Chattanooga

Additional Author | Yu Liang,

The University of Tennessee at Chattanooga (UTC) is establishing a program of excellence in Quantum Information Science and Engineering (QISE). A fundamental aspect of that program is a series of innovative curriculum developments. In Spring 2024 UTC faculty launched a four-course undergraduate certificate in QIST (i.e., Quantum Information Science and Technology). The four courses are: (1) Introduction to QIST, PHYS/CPSC/MATH 3810, a team-taught cross-listed course; (2) Mathematical Concepts in QIST, MATH 3720; (3) Physics Concepts in QIST, PHYS 4810; and (4) Intro to Quantum Computing, CPSC 3280. The certificate program and each of the four courses have completed the curriculum approval process. Plans are underway to develop a similar certificate program at the graduate level. Academic departments are considering the addition of a quantum concentration in their bachelor's and master's degrees. UTC has an interdisciplinary PhD program in Computational Science with three concentrations: computer science, engineering, and math. A fourth concentration, in quantum science, is in the planning stage. We will also discuss plans for non-credit certificates to directly train the industry workforce, and pre-college outreach efforts.

(SUN-POS-G-617) | Poster Presentation Traditional | A Simplified Single-photon Quantum Key Distribution Setup for a Quantum Teaching Laboratory

Presenting Author: Danyel Cavazos-Cavazos, The University of Chicago

Additional Author | Hannes Bernien, The University of Chicago

Additional Author | Alexander A. High, The University of Chicago

Cryptography presents one of the clearest applications of quantum information science occurs, where the fundamental principles of quantum physics can be harnessed to encrypt messages in a way that is secure and can unambiguously reveal the presence of an eavesdropper. Here we present a simplified experimental setup that demonstrates the core concepts of quantum key distribution while using minimal resources and maintaining a small footprint. The experimental design is compatible with both a multi- and single-photon implementation, and it also can demonstrate the presence of an eavesdropper that is detectable in the communication error rate. We will discuss the successful implementation of this setup at the University of Chicago, in a quantum teaching laboratory course targeted at the undergraduate level.

(SUN-POS-G-619) | Poster Presentation Traditional | Surface Characterization Techniques in an Undergraduate Course

Presenting Author: F Fatima, Roanoke College

Surface characterization is critical for developing novel nanostructures and understanding their chemical, physical, mechanical, and electronic properties. It identifies the proper materials for specific applications. Surface characterization consists of a range of techniques such as microscopy which scans the surface at atomic level and spectroscopy that provides important information about the electronic structure of the surface. Here, a teaching outline of an undergraduate Material Science special topic course is described. Synthesize, characterization and applications of different nanostructures were included to the course syllabus. The students acquired hands-on experience on Scanning Tunneling Microscopy/Spectroscopy (STM/STS) and Atomic Force Microscope (AFM).

DEI Posters I

(SUN-POS-H-701) | Poster Presentation Traditional | Exploring Access in Computing and Active Learning Course Materials

Presenting Author: Theodore Bott Bott, Michigan State University

Additional Author | Daryl R McPadden, Michigan State University

Over the last several decades, computing and active learning have been incorporated into physics and other STEM degree programs. While research has examined the learning gains, attitudes, and many other aspects of these classrooms, there has been little work done to understand these classrooms through an accessibility lens. With up to 20% of postsecondary STEM students identifying as disabled, combined with the fact that computing and active learning techniques pose unique barriers for disabled students, it is important that we begin investigating the accessibility of computational and active learning settings. In this work, we present results of a document analysis of CMSE 201, a large-scale introductory applied data science course at Michigan State University that teaches python programming in an active learning environment via Jupyter notebooks. Since the ability to engage with a course's curricular materials comprises a significant portion of the course's overall accessibility, we conducted a document analysis which sought concrete examples of alignment and unalignment between the course's curricular materials and accessibility standards like the Universal Design for Learning (UDL) framework. From this analysis, we make recommendations to curriculum designers and instructors on ways to design for better accessibility in their respective computational & active learning environments.

(SUN-POS-H-703) | Poster Presentation Traditional | Examining Two Professional Learning Communities of Physics Teachers in Pursuit of Culturally Relevant Pedagogy

Presenting Author: Clausell Mathis, Michigan State University

Co-presenting Author | Andrea Wooley, Michigan State University

Co-presenting Author | Abigail Daane, South Seattle College

Additional Author | Linsey Brennan, Michigan State University

Additional Author | Christina Schwarz, Michigan State University

Additional Author | Mathilda Smith, Michigan State University

Although there is a desire to adopt culturally relevant teaching practices, many physics teachers express challenges, especially without practical examples. Given the lack of diversity in physics students, there is a need for a reformed approach to instruction to reach more diverse learners. Our study examined how two professional learning communities (PLC) of physics teachers worked together to develop culture-based approaches to physics instruction, where students use their cultural resources to engage with physics ideas. We aimed to understand the process through which teachers develop the curricula and any shifts that occur within their teaching identity due to participating in the PLC. Our study employed a qualitative design, thematically examining video recordings of two groups of eight physics teachers as they develop curricula. Interviews of teachers were conducted to examine shifts in their physics teaching identity by exploring teachers' conceptions of self, others, knowledge, and pedagogy. Key findings show that teachers developed curricula emphasizing social justice, maintaining rigor, helping students merge content and scientific practices, and fostering critical analysis around physics ideas. Interview analysis revealed teachers experiencing favorable shifts in their conceptions of pedagogy and knowledge. Our findings shed light on various strategies for developing culture-based approaches to physics instruction.

(SUN-POS-H-705) | Poster Presentation Traditional | Call to Action: Exploring the Accommodations of Disabled Physicists

Presenting Author: Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Co-presenting Author | Liam McDermott, Rutgers University

Many post-secondary tenured and tenure-track, teaching, and professor of practice physics faculty are expected to work 60 to 80 hours a week due to large teaching, research/ scholarship, and/or service loads depending on the type of post-secondary institution. Additionally, this expectation of working long hours is reflected in the loads of graduate students and post-doctoral researchers. These high workloads are not healthy for anyone, especially disabled faculty and disabled students within a physics department. Unfortunately, many disabled physicists cannot find accommodating jobs that allow them to continue working part-time in physics. Oftentimes, the only part-time or 40-hour weekly physics positions are adjuncts with incredibly low pay, often on the order of $1K per credit-hour. Through this "editorial" poster, we present a call-to-action by sharing the narratives of disabled physicists in order to create more awareness about what it means to be a disabled physicist in academia.

(SUN-POS-H-707) | Poster Presentation Traditional | Characterizing Circumstantial Barriers to Attending Physics REUs: A Pilot Study

Presenting Author: Jonan-Rohi Plueger, University of Colorado, Boulder

Additional Author | Bethany R Wilcox, University of Colorado, Boulder

The benefits of undergraduate research experiences (UREs) have been established in many studies, and various discipline-based education research fields, such as biology and chemistry, have done extensive work to optimize UREs in their fields. In PER, however, the investigation of physics UREs is new and growing. In this study, we interviewed grad students at an R1 institution about their experiences with NSF Research Experiences for Undergraduates (REUs) to characterize the barriers to REU access presented by a student's home circumstances and the geographical dislocation inherent in many REUs. In this poster, we discuss our findings and offer space for attendees to interact with the ideas we present.

(SUN-POS-H-709) | Poster Presentation Traditional | Preparing Teachers to Support All Students in the UTeach Model

Presenting Author: John Stewart, West Virginia University

This poster describes a promising model which adds additional training to the UTeach STEM teacher preparation program. This talk will describe a strategy for preparing students to teach in high-needs environment within the UTeach model. This preparation helps mentor teachers and students to recognize their own biases and to recognize how these biases are inadvertently communicated to their students. Once this negative communication is identified and eliminated, it can be replaced with positive messages that encourage all students to pursue academically challenging coursework. This preparation has been successfully tested in urban environments. The additional training generated strong improvements in understanding of equity and inclusion in these future teachers.

(SUN-POS-H-711) | Poster Presentation Traditional | Designing and Implementing a One Credit First-year Physics Seminar to Increase Retention of Physics Majors

Presenting Author: Jolene Johnson, University of Wisconsin River Falls

In Fall of 2023 I developed a 1 credit freshman seminar course for physics majors. This course was developed in response to a decrease in the number of physics and engineering dual degree majors persisting in the program particularly post covid. As a department we identified difficulties students were encountering in the school and program and tried to provide additional support through this course that meets once per week. The course includes lessons on career options, problem solving, physics specific study skills, diversity in physics and group projects in electronics and mechanics. All students interested in physics and engineering were encouraged to enroll in the course even if they were not able to start in Physics I while they completed math prerequisites. In general student feedback on the course first version of the course (Fall 2023) was very positive and there was a 100% retention rate of students in the major for those who were enrolled in the course. I will also discuss changes planned for the course based on the first trial run and the literature review being completing as part of an Evidence Based Teaching Fellow program.

(SUN-POS-H-713) | Poster Presentation Traditional | Water is Life: Project-based Learning to Reroute the Dakota Access Pipeline

Presenting Author: Julie Hammond, University of Massachusetts Amherst

In operation since 2017, the Dakota Access Pipeline transports crude oil from North Dakota to a refinery plant in Illinois. While oil is regarded as a primary fuel source, concerns have emerged about its environmental impact. Combustion of fossil fuels produces greenhouse gases which contribute to climate change. Oil spills pollute groundwater and lead to contaminated drinking water. While preliminary blueprints for the Dakota Access Pipeline circumvented Native lands, the company which constructed the pipeline chose to reduce costs by designing a shorter route which skirts the Standing Rock reservation and traverses sacred burial grounds. Protests, led by indigenous youth, have been ongoing; the U.S. Army Corps of Engineers have been involved on multiple occasions. Rerouting the Dakota Access Pipeline to circumvent indigenous lands and improving the pipeline's integrity to reduce the risk of an oil spill is of paramount importance; this provides a novel opportunity for project-based learning in the science classroom. Curricular topics include fluid dynamics, geology, and cross-disciplinarity with social science. This paper outlines a curriculum involving Project-Based Learning that encourages youth to enact Critical Science Agency to reroute the Dakota Access Pipeline and promote social justice for indigenous peoples.

SUN-POS-F-501) | Poster Presentation Traditional | Empowering Physics Education with ChatGPT: From Lesson Planning to Student Support

Presenting Author: Hannu Turunen, Metropolia University of Applied Sciences

This presentation explores the practical application of ChatGPT in enhancing physics education, focusing on its use in lesson planning, creation of assignments, development of learning materials, and test construction. It also examines ChatGPT's role in providing personalized learning support directly to students. The utility of ChatGPT as a tool for educators in designing curriculum-aligned, engaging content, and for students in seeking clarifications, understanding complex concepts, and enhancing problem-solving skills, is highlighted. A practical test of ChatGPT's effectiveness in these areas, alongside a collection of firsthand experiences from implementing it in a physics classroom, forms the basis of this study. Additionally, a survey conducted among students reveals their perceptions, usage patterns, and the impact of ChatGPT on their learning process. The findings aim to offer insights into the benefits and challenges of integrating AI tools like ChatGPT in educational settings, providing a roadmap for educators looking to adopt technology-driven teaching methods.

(SUN-POS-F-503) | Poster Presentation Traditional | Learning About the Magnetic Field of a Wire Through the Use of Augmented Reality

Presenting Author: Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

Additional Author | Megan Kelly, Siena College

Students in physics and engineering encounter challenges grasping abstract 3D representations of electricity and magnetism principles. MARVLS: Physics II E&M, an augmented reality (AR) application tailored for smartphones and tablets, offers a platform for students to engage with various conceptual models pertinent to a second-semester introductory physics curriculum. This investigation delves into the process through which students cultivate conceptual comprehension by engaging with an augmented reality rendition of the magnetic field of current-carrying wire within the MARVLS App. Employing a grounded theory approach, we scrutinize insights gleaned from semi-structured interviews with students undertaking guided interactions with the AR model. The findings shed light on how students assimilate manipulable AR visualizations to enhance their understanding of magnetism principles.

(SUN-POS-F-505) | Poster Presentation Traditional | Raspberry Pi, Shift Registers, and Stepper Motors Utilized in a DIY 2-D Plotter Design

Presenting Author: Ariana Burge, 400 Granville Dr., Riva, MD 21140

Co-presenting Author | Mary Ruth Putnam, 400 Granville Dr., Riva MD 21140

Additional Author | Murray S. Korman, Dept. of Physics, United States Naval Academy

A low cost 2-D plotter is a fun project to build using Python code on a Raspberry Pi 3B+. Generate a square wave clock signal to control a GPIO output pin high for a duration and then low for the same duration. Repeat for the number of cycles (steps) required. Assign two other GPIO pins high or low to control the cw or ccw direction of the stepper motor. These output pins are connected to the 74LS194 universal 4-bit shift register to allow registers Q0=1, Q1=1, Q2=0, Q3=0, to shift left or right for each clock pulse. A bipolar stepper motor driver-controller board L9110S will provide enough pulsed current control to the 4-wire "mini stepmotor slide" translation apparatus (for example mpja.com 36740 MS). Two mutually perpendicular linear slides supply the x-y position of a plotter pen. A third motor is described to lift the pen off the writing surface.

(SUN-POS-F-509) | Poster Presentation Traditional | A Technology Stack for Immersive Physics Simulations

Presenting Author: Diego Valente, University of Connecticut

Additional Author | Howard Winston, University of Connecticut - Waterbury

Additional Author | Steven Binz, Salisbury University

Extended reality-based physics simulations hold great promise for enhancing student engagement in introductory physics courses. This technology spans the domains of virtual reality (VR), augmented reality (AR), and mixed reality (MR). Implementing physics simulations as extended reality apps requires integration with a set of technologies and development environments that form the basis of our technology stack (tech stack). In this work, we present a tech stack for developing such applications that consists of the cross-platform Unity game engine, C# programming language, Visual Studio integrated development environment, Photon multiplayer software development kit, and Microsoft's mixed reality toolkit of predefined user-interface components. We describe how our physics simulations are based on a three-way mapping between learning objectives, learning assessment items, and tech stack software elements. Finally, we illustrate elements of our tech stack with a simple app implementation for teaching physics.

(SUN-POS-F-511) | Poster Roundtable | Learning Physics through Coding with the Wipple Programming Language

Presenting Author: Wilson Gramer, Worcester Polytechnic Institute

Wipple is a new programming language and educational platform designed by Worcester Polytechnic Institute student Wilson Gramer. With Wipple, students can learn math, physics, and computer science fundamentals by building their own demonstrations in code. Wipple's physics course teaches mechanics concepts with an emphasis on unit analysis, and guides students toward the solution with helpful error messages when they make mistakes. Demonstrations will be provided and feedback welcomed!

(SUN-POS-F-513) | Poster Presentation Traditional | Improving the Quality of Your Research Design Utilizing AI Research Tools

Presenting Author: Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | Praveer Sharan, Purdue University

Additional Author | Liam McDermott, Rutgers University

The research design process, fundamental to discipline-based STEM education research, guides researchers to make crucial decisions before initiating formal data collection. During this design process, researchers develop their research questions, determine their methodology, select different data collection methods, choose analytical techniques, and identify any flaws within their design. Designed to make the overall research process easier, many Artificial Intelligence (AI) tools now exist to create formal literature reviews, streamline data analysis, and uncover trends within large data sets. These AI tools use Natural Language Processing and Natural Language Generation to process and output text prompts or larger sets of text data, which has sparked interest among qualitative researchers. This poster presents a systematic review of many different generative AI research tools and how these tools can be incorporated into your research. The intention of the poster is to help the community make informed decisions about using AI in their research.

(SUN-POS-F-515) | Poster Presentation Traditional | ChatGPT's New "Personality" Makes it a "Better" Physics Student

Presenting Author: Bor Gregorcic, Uppsala University

In late 2022, a colleague and I reported that ChatGPT was quite bad at correctly answering conceptual physics questions, often making blatantly wrong and even internally inconsistent statements. Furthermore, as teachers, we got really frustrated when we tried to make it recognize its own mistakes and fix them. We perceived its "personality" as very confident in its own wrong answers. We found the chatbot to be frustratingly unresponsive to nudges in the form of "Socratic" questions intended to have it notice the inconsistencies and inaccuracies in its own responses. Since then, ChatGPT's personality has changed. Nowdays, it receives such Socratic questions in a way that projects humility and readiness to correct its own mistakes. I argue that this makes it a "better" student and opens up posibilities for using it as a tool for training existing and future physics teachers in Socratic-style dialogue. This kind of dialogue involves carefully interpreting students' statements and providing feedback in the form of strategically placed questions.

(SUN-POS-F-519) | Poster Presentation Traditional | Can Generative AI Enhance Collaborative Physics Problem Solving?

Presenting Author: Hyewon Jang, Sejong University

Since the emergence of ChatGPT in November 2023, generative AI has been actively used in the educational field. This study aims first to explore the Generated AI-Blended Teaching and Learning Strategies (GAI-BTLs), which integrate generative artificial intelligence to develop key competencies required for STEM (Science, Technology, Engineering, and Mathematics) professionals based on previous research. Secondly, we examine a case study of college students' collaborative problem-solving process using the Interactive Generative AI chatbot(IGAI-bot), discussing the implications of providing it. By analyzing students' behavior when generative AI is introduced into team-based physics problem-solving, this study seeks to identify ways to enhance their future problem-solving capabilities.This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea NRF-2023S1A5A8079973).

(SUN-POS-F-519) | Poster Presentation Traditional | Proactive Implementation of AI in the Classroom - Prospects and Limitations

Presenting Author: Kevin Filip, United States Military Academy

The prevalence of artificial intelligence, especially large language model (LLM) chatbots, continues to increase both in prevalence and capability. We designed a study for the fall of 2024 to analyze usage and impacts of LLM chatbots in a large enrollment undergraduate physics course. In this poster we compare leading LLMs, propose ways to integrate them into the classroom, and address concerns during implementation. The LLM variants which are both widely available and well suited for undergraduate physics education at present include OpenAI's Chat GPT, Google's Gemini, and Meta's Llama. GPT-4o is currently the most feature-rich model variant with a user interface that allows video chat and screen sharing while maintaining a high accuracy. These models can be integrated into studying through dynamic conversation, during class to aid in discussions and note-taking, or used to generate course content. The two greatest concerns using these models are hallucinations and developing an over-dependence on the model. To obviate these it is recommended to always use a reference text for validation and limit usage of models to foster and assess independent critical thinking skills. Our upcoming study in the fall will implement these techniques to quantify student usage of the models and impacts on conceptual understanding.

(SUN-POS-F-523) | Poster Presentation Traditional | A School-tailored Chatbot for High School iIntegrated Science

Presenting Author: Junehee Yoo, Seoul National University

Co-presenting Author | Gyeongmo Min, Seoul National University

We developed a school-tailored chatbot for first-year high school students, employing open-source software and the Korean Sentence-BERT model for AI-powered document classification. The first-stage dataset was constructed by scrolling data in the Q&A bulletin board of educational broadcasting. After distributing the beta version to students at a specific school, the researcher revised and added inappropriate or insufficient responses from the chatbot by referring to the student's responses. The number of interactions between students and chatbots was 3,457, and 30,819 datasets were constructed. Text mining identified student input terms encompassing not only science-related queries but also aspects of school life such as assessment scope. Topic modeling using BERTopic on Sentence-BERT-based representations categorized 88% of inquiries into 35 topics, shedding light on common student interests. A year-end survey confirmed the efficacy of the carousel format and the chatbot's role in addressing curiosities beyond integrated science learning objectives. This study underscores the importance of developing chatbots tailored for student use in public education and highlights their educational potential through long-term usage analysis.

(SUN-POS-F-525) | Poster Presentation Traditional | Facilitating Student Coding Proficiency using a Scripting-Integrated Physics Engine

Presenting Author: Mikail Khan, Purdue University

Co-presenting Author | N. Sanjay Rebello, Purdue University

To increase physics students' coding proficiency, we have developed an online app that enables students to script physical laws into an interactive environment. The app features a 2D interface filled with objects which can be interactively inspected or manipulated, minimal built-in physics, and a scripting engine using the Rhai language. A standout feature is the ability for students to interact with the scene while debugging and after finishing the code, facilitating a deeper intuition. Our engine is also fairly "batteries-included" without losing flexibility, such that students can disable built-in physical laws and reimplement them on their own. Early evaluation shows that students perceived an increase in their coding skills after taking our summer course using these labs.

(SUN-POS-F-529) | Poster Presentation Traditional | Going down an inclined plane with a large language model

Presenting Author: Ralf Widenhorn, Portland State University

Additional Author | Ryan Sissons , Portland State University

Additional Author | Justin C. Dunlap, Portland State University

This study examines how OpenAI's GPT-4 Large Language Model (LLM) responds to variations of an introductory physics problem involving an object going down an inclined plane. For different permutations, depending on the object, action-verb, and property of the incline both sliding and rolling motion was possible. The LLM's responses were analyzed based on the problem's setup, the assumptions made, and the problem-solving approach. The LLM used conservation of energy for all responses. When discussing rolling versus sliding, it gave more weight to the type of object than the action verb or the property of the incline than a physics expert or even a physics student might. While almost half of the responses were assessed as expert-like, the LLM generally did not specify all necessary assumptions. It also failed to recognize conflicting information for contradictory scenarios. This study offers insights into how LLMs tackle problem variations and underscores the importance of adapting education to AI's evolving abilities.

Grading and Assessment Posters I

(SUN-POS-I-801) I Poster Presentation Traditional I Implementing Skill/Competency-based Grading in Introductory University Physics

Presenting Author: Martin kamela, Elon University

Co-presenting Author | Kyle Altmann, Elon University

Standards-based grading has been gaining popularity in the K-12 setting. In this poster we present some thoughts on implementing skill/competency-based grading in University Physics II, the second half of a two-semester introductory physics sequence that focuses on waves, electricity, and magnetism. Students wrote weekly quizzes, where every other quiz offered a second attempt to demonstrate mastery of the topics from the previous quiz. Questions on quizzes, and in homework assignments, were labelled by specific skill at either satisfactory or advanced competence level. The numerical grade was determined based on the fraction of satisfactory and advanced-level skills students attained.

(SUN-POS-I-803) I Poster Presentation Traditional I Modeling Student Exam Scores Using Non-normal Probability Distributions

Presenting Author: Alexander Shvonski, Massachusetts Institute of Technology

Additional Author | Aidan MacDonagh, Massachusetts Institute of Technology

Additional Author | Byron Drury, Massachusetts Institute of Technology

Additional Author | Shams El-Adawy, Massachusetts Institute of Technology

Additional Author | Michelle Tomasik, Massachusetts Institute of Technology

Student exam scores are not normally distributed, but intuitive models of alternative, non-Gaussian probability distributions are lacking. We present an analytic probability density function to model student exam scores, wherein exam scores are determined by transforming from a range of normally distributed student "abilities" to a range of scores from [0,1] using a cumulative distribution function. We highlight intuitive features of this model and also interpret other related probability distributions (e.g., beta distribution) in this context. We fit our model to histograms of exam scores across many semesters and classes and compare goodness of fit parameters. Finally, we discuss the moments of this new distribution and other salient characteristics. We anticipate that this model will aid our interpretation of physics assessments in the future.

(SUN-POS-I-805) I Poster Presentation Traditional I Student Performance on Exam Problems Chosen from Large Isomorphic Problem Banks Generated with the Assistance of AI

Presenting Author: Emily Frederick, University of Central Florida

Co-presenting Author | Zhongzhou OSWTP3BHNPTP Chen, University of Central Florida

Conventional exam problems need to be hidden from students prior to the exam, and are oftentimes not well aligned with problems that students previously practice on. We explored an alternative assessment scheme by creating a large bank of isomorphic problems with the assistance of Generative AI (GPT-3.5 Turbo). Isomorphic problems targets the same learning objective but contain different surface features. Students are able to openly access the bank for practice one week prior to an actual midterm exam. We compare students' score on two types of problems on the exam: One problem randomly selected from the problem bank, and one new isomorphic problem not included in the bank. The comparison was conducted for both a conceptual question and a numerical question. We estimate students' level deep understanding of the underlying principles versus merely rote learning, by comparing their performance on the two type of questions.

(SUN-POS-I-807) I Poster Presentation Traditional I Homework Corrections in Upper-division Physics Courses: Student and Instructor Motivations

Presenting Author: Molly Griston, University of Colorado Bould

Additional Author | Bethany R Wilcox, University of Colorado Boulder

It is widely recognized that problem solving is a vital skill for physics students to learn. One element of expert-like problem solving is reflecting on one's solution and iterating as necessary. In upper-division physics courses, students are typically given ample opportunity to practice problem solving in the form of homework; however, there is often not much structure in place for reflection and iteration. One avenue for formalizing this revision process is homework corrections, in which students earn points back for submitting corrections to their homework. While potential benefits of homework corrections are apparent, instructors have also voiced concerns, and further research is necessary to understand if and how homework corrections can be implemented effectively. As part of a larger study analyzing the implementation of and participation in homework corrections, we present instructor motivations for offering homework corrections and student motivations for engaging with them.

Intro Posters I

(SUN-POS-D-401) I Poster Presentation Traditional I Kinematic Graphs? What a Waste!

Presenting Author: Thomas Foster, Southern Illinois University Edwardsville

It is well known that many students struggle to solve kinematic problems when the use of kinematic graphs (x-vs-t; v-vs-t; a-vs-t) is required. We even know why this is; most students do not know how to interpret graphs. In concert, we know that representations help students learn physics by downloading information out of their heads and onto the paper in a manner which is easily retrievable later. However, this poster is going to make the argument that in most kinematic problems, kinematic graphs or even motion graphs are overkill, waste student's mental resources, and lead to failure to learn. In short, the kinematic graphs are the wrong representation for solving kinematics problems. We claim to have a better one. Stop by this poster and give us a piece of your mind.

(SUN-POS-D-403) I Poster Presentation Traditional I Hey, You Got Your Physics in My Calculus! Piloting a "Calculus I for Physical Sciences" Course

Presenting Author: Sara Callori, Department of Physics and Astronomy, California State University San Bernardino

Additional Author | Jeremy Aikin, Department of Mathematics, California State University San Bernardino

Mathematical preparation for introductory physics courses can be challenging to address, as there is often little individual instructors in one department can do to address courses from another. Some institutions have developed concurrent calculus/physics sections, but this can be challenging to implement. Here, we present a pilot approach that embeds physics in a calculus course with dual aims: 1) easing the transition between using calculus in a math context to using the same principles in a physics course and 2) making introductory calculus concepts more real and tangible. The hallmark of our approach is turning one "lecture" unit of the class into a three-hour weekly lab session, with new laboratory activities designed to be based around topics from introductory physics courses while stressing application of calculus topics to the day's experiment. Additionally, the course is co-taught by math and physics faculty members, allowing us to highlight physical science applications directly in the lectures as well. In this poster we share our curricular approaches and laboratory activities as well as student work and impressions of the course.

(SUN-POS-D-405) I Poster Presentation Traditional I Lecture/Studio at USC: Two Years and Counting

Presenting Author: Alice Churukian, University of South Carolina

Additional Author | David J. Tedeschi, University of South Carolina

Over the last several years, the Physics and Astronomy Department at the University of South Carolina has been working to improve the learning gains of the students enrolled in both introductory physics sequences. We have adopted the Lecture/Studio format and are in the process of adapting the materials developed at the University of North Carolina at Chapel Hill to meet the needs of our students. Starting with the calculus-based sequence, we are rolling out one new course per year. Fall 2022 saw the implementation of the first semester course and Fall 2023 we expanded into the second semester course. In this poster we will evaluate the new program thus far including student and faculty perceptions and learning gains based on FCI and CSEM performance. We will also discuss our experience with the expansion into the second semester course and ongoing room renovations.

(SUN-POS-D-407) I Poster Presentation Traditional I Revising an Introductory Physics with Calculus Sequence for Student success

Presenting Author: Jax Sanders, Marquette University

The introductory physics with calculus sequence at Marquette University experienced a statistically significant increase in D-F-Withdraw (DFW) rate between 2015-2018. This motivated course reform effort with the goals of reversing the DFW increase, while holistically integrating modern physics and recruiting physics majors. The revision leveraged detailed rubrics to allow for consistent and time-effective grading of free-response homework and exams, eliminating automated assessments. These rubrics are framed in the TRIAGE model of problem solving developed by Melissa Vigil, and the rubric expectations are reinforced in class, formative, and summative assessments. Office hours were moved to a common space and framed as a "Physics Help Room". The revised course was taught in academic years 2022-23/23-24 and observed DFW rate decreased from 25-35% to 15-20% while integrating units in special relativity and quantum mechanics. Additionally, several students from the 22-23 cohort are majoring in physics and/or participating in undergraduate physics research.

(SUN-POS-D-409) I Poster Presentation Traditional I What's New in Matter & Interactions 5th Edition

Presenting Author: Ruth Chabay, NC State University

Additional Author | Bruce `Sherwood, NC State University

Additional Author | Aaron Titus, NC State University

Additional Author | Stephen Spicklemire, University of Indianapolis

The fifth edition of Matter & Interactions (available in January 2025), will provide better support for both students and instructors. This edition is designed for digital media, and includes both videos and interactive simulations. Text improvements include clear learning objectives for each section; reorganization of chapters to present key concepts and methods early; revised treatment of difficult topics. Support for computational modeling has been significantly increased, including: the introduction of all key computational ideas in the text; complete sample programs in the text; videos explaining key concepts and step-by-step model development; emphasis on comprehending and modifying computational models; more accessible computational activities.

(SUN-POS-D-411) I Poster Presentation Traditional I Integrating Computation Through Coding as a Calculator

Presenting Author: Aaron Titus, North Carolina State University

Additional Author | Ruth Chabay

Additional Author | Bruce Sherwood

Additional Author | Steve Spicklemire, University of Indianapolis

If a teacher or department wants to integrate computation into a physics course, how should they do it? We suggest starting by teaching students to write code for all calculations for in-class activities, homework, and exams. This has the following advantages over a calculator: (1) students can find and fix errors without repeating all the steps in the calculation; (2) students define variables and write calculations symbolically; (3) students quickly become comfortable writing, reading, and debugging code; and (4) students believe they can code and believe it is relevant to the course. A significant key for students adapting this new way of doing calculations is to allow them to use it for tests. We will make recommendations, and we will describe how you can use VPython as a calculator on tests.

K-12 Posters I

(SUN-POS-A-101) I Poster Presentation Traditional I Building Student Interest in Quantum Careers: The Pathways to Quantum Immersion Program

Presenting Author: Jessica Rosenberg, George Mason University

Additional Author | Nancy Holincheck, George Mason University

Additional Author | Benjamin Dreyfus, George Mason University

The Pathways to Quantum Summer Immersion Program introduces high school students to key quantum concepts and the jobs in quantum. The program has been run twice with a total of 37 participants. The program includes: (1) a two-week virtual program focused on helping students understand basic quantum concepts, (2) a one-week in-person experience in which students build on their understanding of the quantum key concepts and visit research labs, companies engaged in quantum, and an organization focused on quantum policy, (3) an optional follow-up in which students create a poster on their vision of future uses for quantum, and (4) an optional (application required) extended research experience in quantum. We examine survey responses and focus group interviews with participants to understand what students know about quantum careers and how understanding of their options and interactions with peers and experts through this program impacts their thinking.

(SUN-POS-A-103) | Poster Presentation Traditional | Developing Three-Dimensional Learning Assessments Using Generative-AI through Prompt Engineering

Presenting Author: Amogh Sirnoorkar, Purdue University

Recent reports in higher education have called for developing next-generation assessments that promote authentic knowledge-building practices. To facilitate this objective, "Three-Dimensional Learning (3-DL)" framework has been extensively adopted. This framework characterizes science learning along three "dimensions" namely (i) disciplinary core ideas - concepts central to understanding of a discipline, (ii) cross-cutting concepts - ideas that span across multiple disciplines, and scientific practices - disciplinary practices that are key to generating new knowledge. However, educators have highlighted several challenges in developing such assessments including contextualizing them in real-world scenarios. We seek to address these challenges by leveraging Generative-Artificial Intelligence through developing a prompt template customizable to the instructors' choices of content areas, scientific practices, core ideas, and cross-cutting concepts. Exemplar assessments generated from the template along with insights from piloting in introductory physics courses are discussed.

(SUN-POS-A-105) | Poster Presentation Traditional | Ensemble Projects—A New Take on Group Projects

Presenting Author: Sarah McGregor, Keene State College

In general science courses students often struggle to appreciate topics beyond their disciplinary boundaries. This challenge can persist in Introductory Astronomy, especially when engaging with some content-heavy topics. To address this, Ensemble Projects are introduced—an alternative assessment that fosters discipline connections and creativity. Groups collectively choose from predefined topics to act as the group's theme. Each member of the group must create a project inspired by this theme, and encompassing at least three relevant facts. This allows for both individual expression and accountability, while encouraging group support. From fashion, logos, and artwork to literature, songs, and restaurant designs, students explore connections with astronomy. This poster outlines the Ensemble Project implementation, covering topic selection, assignment parameters, and examples of students' creations. Discover how this approach reinforces the connection between astronomy and our world, enhances engagement, and acts as both an alternative assessment and content review for later assessments.

(SUN-POS-A-107) | Poster Presentation Traditional | Mission to Mars Challenge: Where Physics meets Engineering and Computer Science

Presenting Author: Robert Krakehl, Manhasset Secondary School

This poster will discuss the development and implementation of the Mission to Mars Challenge. A low cost robotics challenge that includes programming challenges, engineering designs, and purposeful use of many physics units including kinematics, dynamics, circuits, and more. This challenge demonstrates to students first hand how these three fields need to work in conjunction in order to succesfully complete a task. From middle school to post-secondary, this can work for all age groups. The challenge requires students to program a robot for autonomous motion; use different sensors to navigate an unknown territory; work with external teams to solve on the fly tasks together; and design, build, and test different apparatus to solve unique game based problems as they arise. Unlike other robotics compeitions that exist, this can all fit inside of your classroom and is relatively inexpensive to implement. Additionally it allows for a hands on, engaging, and compeitive method of teaching physics!

(SUN-POS-A-111) | Poster Presentation Traditional | Climate Change Teaches Energy, Examples and Details

Presenting Author: Thomas Gibbons, Clinton Community College, Retired

In a contributed talk, Climate Change Teaches Energy, I presented reasons why physics students could work problems or listen to examples relating heat absorbed by earth systems to the temperature change of these systems using recent research data. The simplest such problem relates the portion of the earth's ice that has melted to heat absorbed. Problems involving the earth's atmosphere, oceans, and solid land are complicated by non-uniform heat absorption and non-uniform temperature rise. Students would need to have these simplified. They can also relate total heat absorbed by the earth to the earth's energy imbalance, as measured independently by satellite, thus obtaining evidence for our conception of climate change. Examples will be given here of energy imbalance calculations as well as suggestions for suitable simplifications.

(SUN-POS-A-113) | Interactive (e.g. panel, round table discussion, hands-on activity | Building Bridges to Interdisciplinary Collaboration

Presenting Author: NADENE KLEIN, Douglas County School District

This session will give examples and strategies for teachers of different content courses to collaborate on interdisciplinary projects with their students. The examples given include physics with geometry and astronomy with probability/statistics. Structures/framework, outcomes, and student testimonials will be shared.

(SUN-POS-A-115) | Poster Roundtable | Open Ended Labs

Presenting Author: NADENE KLEIN, Douglas County School District

This poster presentation will give examples and strategies for how to manage your students planning their own labs. Becoming a facilitator in the lab can be scary for high school teachers, but when done right the benefits to the learner are incredible. In this process, students determine their own experimental question and experimental process.

(SUN-POS-A-117) | Poster Presentation Traditional | Learning About the Moon as a Scientifically and Culturally Important Place

Presenting Author: Dimitri Dounas-Frazer, Lakeside School

The physics teachers at Lakeside School have developed a month-long project-based unit focused on learning about the moon as a scientifically and culturally important place. Students use energy-based models to relate the size and shape of a lunar crater to the mass and impact speed of the asteroid that created the crater. In parallel, students research a story about the moon from a culture of their choice. The project culminates in a poster session open to the whole school. After presenting posters, students participate in a week-long unit focused on Indigenous Polynesian conceptions of land and the legacy of colonization in planetary science. Finally, students engage in critical discussion of ongoing efforts to establish a permanent human presence on the moon.

(SUN-POS-A-119) | Poster Presentation Traditional | Connecting Middle Schoolers to Physics Careers

Presenting Author: Gabriella Kukon, The College of New Jersey

Additional Author | AJ Richards, The College of New Jersey

Prior work by our research group has indicated that many middle- and high-school students do not know about the variety of careers that a physics career can lead to. Nearly all of them see "engineer" or "teacher" as the only possible destinations for a physics graduate. In this talk, we describe an intervention we designed in which we developed a series of 40-minute modules, each of which explores a physics topic and a career closely associated with that topic (e.g., circuits and electrician), with the goal of exposing K-12 students to a wider range of physics-related careers. We piloted the modules in a local middle school classroom and collected reactions from the students and teacher. This presentation will describe the modules, present some of the feedback we received from the pilot, and detail the revisions we made in response.

(SUN-POS-A-121) I Poster Presentation Traditional I Smithsonian DataLabs: Online laboratories on light, color, and other worlds

Presenting Author: Mary Dussault, Center for Astrophysics | Harvard & Smithsonian

Co-presenting Author | Jim Kernohan, Milton Acadamy

Smithsonian DataLabs are two evidence-based online laboratories aimed at engaging students in real-world data analysis, interpretation, and sense-making, and the use of data as evidence to support scientific claims and reasoning (Gould et. al, 2014). Developed by scientists and educators at the Center for Astrophysics | Harvard & Smithsonian (CfA) in partnership with a diverse group of teacher participants and multi-disciplinary advisors from the Smithsonian Institution, the two DataLabs support student-centered, inquiry-based, and cross-curricular learning for high-school physics, chemistry, astronomy, and earth science students and teachers. The Spectrum Lab and DIY Planet Search are freely available interactive technology-enabled learning environments with associated instructional materials that feature scaffolded exploration and analysis of real data--both professional datasets and data that students collect themselves. In the Spectrum Lab, students investigate light and color phenomena through hands-on materials and through an online data visualization tool that enables them to explore spectra from many disciplines, from astronomy to arts and cultural heritage. In DIY Planet Search, classrooms use the CfA's MicroObservatory Robotic Telescopes to gather, analyze, and interpret their own observational data to search for the signals of planets orbiting distant stars - so-called exoplanet transits.

*Gould, R., Sunbury, S., & Dussault, M. (2014). In praise of messy data. The Science Teacher, 81(8), 31.

(SUN-POS-A-123) I Poster Presentation Traditional I The Framework of Engineering Thinking in Science Education

Presenting Author: Yubin Xu

At present, the goal of international education focuses on the cultivation of core cognitive abilities—so as to enhance creativity and advanced thinking abilities. engineering thinking in engineering course is as important as scientific thinking in the traditional science course, two types of thinking both can improve the core competence of students. We construct a engineering design thinking framework based on the inquiry process. The framework reveals the important thinking skills in the process of engineering design, and links the elements of thinking skills logically. It provides an important theoretical guidance for us to carry out engineering education in K-12 teaching.

(SUN-POS-A-125) I Poster Presentation Traditional I Robotics Projects in Introductory Physics

Presenting Author: Jon Malvik, O'Fallon Township High School

Science and physics course enrollment in the upper-level classes have declined in recent years at our high school. Taking an introductory course in physics in high school is important for future success of STEM majors. How can we reimagine physics curriculum to promote enrollment and sustain excitement over the traditional model? Current research indicates promising levels of engagement in robotics-oriented physics investigations. An action research project was initiated in three on-level physics courses. Participants were mainly college-bound 11th and 12th grade students (n=43).This study was conducted over a two-week unit on uniform circular motion. Students were tasked with designing and programming a rotating platform to perform in a class competition. Students were given a 6-point Likert survey before and after the unit. Post-unit surveys indicated growth in student feelings of self-efficacy and attitudes toward STEM. The results suggest including novel, robotics-related tasks can build student confidence and create a positive perception of the class. Creating an achievable, properly scaffolded project and providing time for tinkering were observed to be important variables in the project. Future research is needed on how effective these types of integrations help build physics content knowledge.

(SUN-POS-A-127) I Poster Presentation Traditional I Developing Problem Solving Skills with "Thin Slicing" From Building Thinking Classrooms

Presenting Author: Marianna Ruggerio, Auburn High School

In the text, Building *Thinking Classrooms in Mathematics* one of the strategies used with vertical whiteboarding is called "thin-slicing" the method provides students with the opportunity to work with a particular skill in increasing levels of complexity as they are ready. This allows for adaquete differentiation of the classroom. At the end of the sequence the process of consolidation and note-making helps construct a cohesive mental model for students in the class. This poster will describe the cycle as executed in a high school AP Physics course.

Labs/Apparatus Posters I

(SUN-POS-E-451) I Poster Presentation Traditional I Sensing the World Around You

Presenting Author: Valarie Bogan, National Radio Astronomy Observatory (NRAO)

The world around us is filled with radio waves. We use this type of energy every day to send and receive messages, stream videos, forecast the weather, track wildlife, study outer space, and so much more. However, the section of the electromagnetic spectrum used for this information exchange is small and getting crowded. With new uses of radio frequencies coming online every year, we must find a way for these uses to coexist without interfering with one another. This poster describes a citizen science project that allows individuals to learn about the uses of radio frequencies in their community and serve as a volunteer monitors of radio frequency use.

(SUN-POS-E-453) I Poster Presentation Traditional I Developing and Piloting an Introductory Open Source Astronomy Lab Manual

Presenting Author: Michael Frey, Quinsigamond Community College

Additional Author | Raymond Johnson, Quinsigamond Community College

Co-presenting Author | Andria C. Schwortz, Quinsigamond Community College

Co-presenting Author | Veronika Akerman, Quinsigamond Community College

Co-presenting Author | Andrew Perella, Quinsigamond Community College

While many astronomy teaching tools have been published, such as dozens of textbooks, a few workbooks, and multiple online homework systems, there is a dearth of published astronomy lab manuals. The more than a dozen internal departmental astronomy lab manuals freely available online demonstrate a lack of standardization of introductory astronomy (Astro 101) lab content and skills, which makes it difficult for new instructors to know where to start, or for instructors in poorly funded departments to find sufficient resources to match existing labs. Here we present a series of labs developed to span the full introductory curriculum (from the methods and scope of astronomy, to extragalactic astronomy) and including multiple lab styles (including using physics equipment, digital planetaria, naked eye observations, and small telescopes). We also show some student submissions and impressions from piloting these labs at a community college in Massachusetts, USA.

(SUN-POS-E-455) | Poster Presentation Traditional | Investigating Wave Properties Using Sound

Presenting Author: David Rakestraw, Lawrence Livermore National Laboratory

This poster presentation will present a series of activities to investigate wave properties using sound. The investigations will use the microphone and speakers on smartphones to conduct the experiments. Experiments begin with measuring the amplitude, period, and wavelength of a single frequency wave produced by a human whistle. The experiment will demonstrate that the solution to a harmonic oscillator is a very good fit to the measured longitudinal wave. Investigations will then demonstrate tools for making conversions between the amplitude and time domain. The next set of investigations will investigate interference demonstrating the principle of superposition of waves with the same and different frequencies propagating through free space. Once the basic principles of superposition are explored, investigations will add the complication of the reflection of waves at boundaries and the establishment of standing waves in both open and closed pipes. Finally, the investigation will introduce voice recognition and the examination of resonances produced from coins. Laboratories materials have been developed to support these activities and will be available as handouts. Visitors to the poster will have the opportunity to conduct the activities and investigate wave phenomena with their peers.

(SUN-POS-E-457) | Poster Presentation Traditional | Optical Tweezers in the Classroom and Beyond

Presenting Author: Adam Green, University of St. Thomas

The incorporation of optical tweezers into our junior/senior level optics course over the past fifteen years has proven very fruitful for our students. The fourteen physics and engineering majors in each class work in pairs to build seven optical tweezers systems from scratch, learn valuable laser alignment skills, and measure their optical trap strengths using latex microspheres. They also use circularly polarized light to spin calcite microcrystals via angular momentum transfer as an introduction to the concepts of optical micromotors. These standard experiments typically occupy four lab periods. Because students find the tweezers labs to be the most exciting of the semester, they frequently wish to continue working with their instruments after the semester ends. This poster is a progress report of some projects that students have created of their own volition. For example, they have trapped E. coli bacteria to study laser-damage thresholds, built multi-trap systems with micromirror arrays, and measured attractive forces between leukemia cells and stem cells in collaboration with researchers at two university cancer institutes. These projects build directly upon our classroom instruction and demonstrate that optical tweezers provide an excellent training ground for students who wish to pursue interdisciplinary optics careers.

(SUN-POS-E-459) | Contributed Talk (12 Minutes) | Intro Lab Revisions for Student Agency

Presenting Author: Cory Christenson, Washington & Jefferson College

The Introductory Mechanics and E&M labs at Washington & Jefferson College were recently completely revised to provide inquiry-based experiences that teach experimental skills. Compared to former or canonical labs, students have much more freedom in what questions they answers and method they use. There is an emphasis on iteration and improvement based on sources of error, and inspiration was drawn from high-profile examples from other schools, as well as various AAPT reports. We will report on the departmentla process for revision, the learning outcomes and how the lab structure addresses those, as well as student responses and the result of an E-CLASS survey before and after revision.

(SUN-POS-E-461) | Poster Presentation Traditional | The Small Oscillations of Polygon Plate Physical Pendulums

Presenting Author: Ernest Behringer, Eastern Michigan University

Additional Author | Ashley Taylor-Voss, Eastern Michigan University

Additional Author | Marshall Thomsen, Eastern Michigan University

Physical pendulums made from plates have long been used in instructional labs and can be rich systems for experimental investigation and modeling. Here, we describe the results obtained with laser-cut acrylic plate pendulums in the shape of regular polygons – triangles, squares, and hexagons – specifically, measurements of the period of small oscillations for different suspension points. The general expression for the small oscillation period of an -sided regular polygon reproduces the measurements very well. Students with access to a laser cutter can design their own N-sided variants and thereby gain design and construction skills. Students can be led through the calculation of the total rotational inertia as well as the numerical modeling of the motion, which involves different damping mechanisms. These plate pendulums can support activities for both introductory and intermediate mechanics.

PER Posters I

(SUN-POS-J-PER101) | Poster Presentation Traditional | Using Curricular Analytics to Model Curricular Flexibility

Presenting Author: Amanda Nemeth, West Virginia University

Additional Author | John Hansen, West Virginia University

Additional Author | John Stewart, West Virginia University

Curricular Analytics (CA) is a quantitative method that analyzes the sequence of courses (curriculum) that students in an undergraduate academic program must complete to fulfill the requirements of the program. When applied to a curriculum, CA returns a complexity score that indicates the overall complexity of the program. This study compares the complexity of undergraduate physics programs at 60 institutions in the United States. This poster will focus on aspects of the study relating to students' flexibility of traversing a curriculum, as well as modifications to a curriculum. Complexity was quantitatively related to curricular flexibility operationalized as the number of available eight-semester degree plans. The number of available degree plans exponentially decreased with increasing core complexity per course. Modifications to a curriculum at one institution were analyzed; a similar relationship between the number of available degree plans and increasing core complexity per course was found.

(SUN-POS-J-PER103) | Poster Presentation Traditional | Investigating the Requirements of a Physics PhD

Presenting Author: Bill Bridges, Kansas State University

Additional Author | Daniel Sharkey, University of Central Florida

Additional Author | William Heredia, University of Central Florida

Additional Author | Rachel Henderson, Michigan State University

Additional Author | Jacquelyn J Chini, University of Central Florida

Additional Author | James T Laverty, Kansas State University

As physics graduate programs adapt to an ever-changing world, it is important to consider an update to their practices of assessing students. This aspect of graduate education is currently not well documented. A lack of how each physics graduate program assesses their students potentially hampers those programs looking to stay updated with their practices. We are investigating the requirements and expectations that graduate programs have for their graduate students. We conducted a landscape study documenting the ways in which students are assessed during their PhD. This includes practices such as written examinations, courses required, and timeline to graduation. These results were compared to determine alignment of the varying practices among universities. With these results we can provide a resource for those programs looking to update their practices and a foundation for further investigations into physics graduate education programs.

(SUN-POS-J-PER105) | Poster Presentation Traditional | Exploring a First-Year Physics Graduate Student's Self-Efficacy Using Mixed Methods

Presenting Author: Vicky Phun, Michigan State University

Additional Author | Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Self-efficacy–or the confidence in one's ability to perform a task–has been shown to be an important predictor of students' STEM academic performance and persistence at the undergraduate level. However, there is limited research on the development of students' self-efficacy during their graduate education experience, particularly among physics graduate students. Considering the wide variety of their responsibilities (e.g., coursework, research, and teaching), there may be unique supports and challenges that influence students' self-efficacy. This pilot study explores self-efficacy domains among a first-year physics graduate student through her participation in an explanatory mixed-methods research design. The design includes the Experience Sampling Method (ESM) coupled with individualized daily journal prompts. In this poster, we will present the results and implications within a physics graduate school context including the importance of capturing non-academic experiences that may influence one's self-efficacy in graduate school.

(SUN-POS-J-PER107) | Poster Presentation Traditional | Examining the Experiences of Physics and Astronomy Graduate Teaching Assistants Using Photovoice

Presenting Author: David Seiden, University of Georgia

Additional Author | Sarah Jane Bork, University of Georgia

Additional Author | Nicholas T Young, University of Georgia

Additional Author | Nandana Weliweriya Liyanage, University of Georgia

Graduate teaching assistantships are the primary funding mechanism for many first-year physics and astronomy graduate students. These time-intensive roles are known to have a large impact within undergraduate introductory courses; undergraduate students often spend as much "face-time" with graduate teaching assistants (GTAs) as faculty members. At the same time, the experiences of GTAs in these positions are equally formative, yet often de-prioritized. This study uses the participatory action research method of photovoice (or photo-elicitation) to examine these experiences. Photovoice studies leverage images gathered by participants in response to a prompt. These images will then be shared and discussed with others (i.e., other GTAs) in a large focus group interview, with the end goal of participants pairing down to 5-10 representative experiences. This poster will present the representative experiences that come from a focus group of physics and astronomy GTAs at a public, research-intensive, south-eastern university. The results will highlight the range of experiences GTA's have (i.e., positive, negative, mixed, and in-between). Findings will suggest areas that educators and graduate program leaders can focus on to promote positive experiences and reduce (or mitigate the impact of) negative experiences for graduate teaching assistants.

(SUN-POS-J-PER109) | Poster Presentation Traditional | Exploring the Directionality of Integration Between the Quantitative and Qualitative Data Sources for a Mixed Methods Research Design

Presenting Author: Carissa Myers, Michigan State University

Additional Author | Dena Izadi, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

The concept of integration in a mixed methods research design is a critical component for making justifiable claims. In this poster, we explore integration during the analysis stage of our study by comparing two directions of linkage between our quantitative and qualitative data sources. Our mixed methods data collection was an explanatory design where we gave short surveys measuring task-level self-efficacy via the Experience Sampling Method (ESM) followed by individualized daily journal reflections. The ways in which the ESM survey responses and daily journal reflections are linked influence the mixed methods inferences drawn from the data regarding students' self-efficacy. Here, we will present an analysis exploring two directions for linking the ESM survey responses with the daily journal reflections: (1) analyzing the ESM survey responses and linking those responses to the daily journal reflections and (2) analyzing the daily journal responses and then linking those responses back to the ESM survey responses. Through examining the concept of integration for our research design, we found that integrating across these two directions influenced the outcomes drawn from the data. These findings might imply refinement to our data collection process.

(SUN-POS-J-PER111) | Poster Presentation Traditional | Exploring Connections Between Student Interactions and Physics Epistemological Beliefs Through a Social Network Analysis

Presenting Author: Dani Romero Mejia, Brown University

Additional Author | Sara Mueller, Brown University

Additional Author | James Valles, Brown University

Significant learning can occur as students work together in formal and informal settings. We seek to understand the connections that form between students in a university-level physics class and the possible impacts on the ways in which students approach their physics learning. Previous studies have looked at students' beliefs about what it means to learn physics - their epistemological beliefs - and how certain beliefs can support deeper learning. Prior research has also focused on care and the sense of belonging that students feel in their physics courses, particularly of women and BIPOC students who have historically been made to feel like they do not belong in the field. Our study builds on the work of another that connects these two ideas, showing that a student's sense of social care in the class has a connection to their beliefs about learning physics. We aimed to further explore this connection between the social environment of a course and students' beliefs about learning physics through a Social Network Analysis (SNA) conducted in an undergraduate electricity and magnetism course at Brown University. In doing so, we hope to add to the body of knowledge encouraging professors to place greater priority on facilitating student interactions within their physics courses.

PER: Assessment Posters I

(SUN-POS-N-PER501) | Poster Presentation Traditional | Visualizing FCI Results for Improving Classroom Instruction

Presenting Author: Geoffrey Nunes, St. Joseph's Preparatory School

The Force Concept Inventory [1] (FCI) is a commonly used instrument for assessing student learning in introductory mechanics classes. This poster introduces a simple spreadsheet based approach to visualizing FCI results across a large group of students that allows rapid assessment of both overall performance, and areas of shared weakness. This view can be used to strengthen future instruction on specific topics where student misconceptions and misunderstandings persist. Using the tool to track student performance over multiple iterations of a course can provide feedback on the effectiveness of specific activities, laboratories, and exercises aimed at strengthening student understanding in these persistent areas of weakness.

[1] D. Hestenes, M. Wells, G. Swackhamer, The Physics Teacher 30, 141 (1992).

(SUN-POS-N-PER503) | Poster Presentation Traditional | Introductory and Advanced Students' Difficulties with Heat Transfer Using a Validated Conceptual Survey Instrument

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | David E Meltzer, Arizona State University

Additional Author | Chandralekha Singh, University of Pittsburgh

We use the Survey of Thermodynamic Processes and First and Second Laws-Long (STPFaSL-Long), a research-based survey instrument with 78 items at the level of introductory physics, to investigate introductory and advanced students' difficulties with heat transfer. We present analysis of data from 12 different introductory and advanced physics classes at five different higher education public institutions in the US in which the survey was administered in-person to more than 1000 students. We find that not only introductory but also advanced physics students have many common difficulties with these introductory thermodynamic concepts after traditional lecture-based instruction in relevant concepts. These findings are consistent with prior research in this area, but our results are also for several new contexts in addition to those used in prior research and for large numbers of both introductory and advanced students. Findings related to common difficulties of students with these concepts before and after traditional instruction in college physics courses can help instructors of these courses improve student understanding of these concepts. These findings can also be valuable for developing effective research-based curricula and pedagogies to reduce student difficulties and help students develop a functional understanding of heat transfer.

(SUN-POS-N-PER505) | Poster Presentation Traditional | Providing Actionable Feedback to Instructors with a New Modular Thermodynamics Assessment

Presenting Author: Michael Freeman, Department of Physics, University of Colorado, 390 UCB, Boulder, CO 80309

Additional Author | James T Laverty, Department of Physics, Kansas State University, Manhattan, KS 66502

Additional Author | Bethany R Wilcox, Department of Physics, University of Colorado, 390 UCB, Boulder, CO 80309

Additional Author | Tyler Garcia, Department of Physics, Kansas State University, Manhattan, KS 66502

Additional Author | Bill Bridges, Department of Physics, Kansas State University, Manhattan, KS 66502

Additional Author | Parker Poulos, Department of Physics, Kansas State University, Manhattan, KS 66502

To improve student learning, measuring it with tools that facilitate informed course modifications is important. Historically, standardized assessments were these measurement tools. To be effective at informing change, assessments need to provide actionable and clear feedback to instructors. Traditionally, this feedback has been average scores/distributions, which are known to be difficult for instructors to interpret. A second issue is that the topics assessed are static, i.e. instructors cannot customize what topics the instrument targets. However, in some courses, including upper-division thermal physics, there is significant variation in what content is taught, motivating the need for modular assessment. Here, we present the goals and features of a newly developed assessment - The Thermodynamics and Statistical Physics Assessment, which is a modular assessment that provides instructors with actionable feedback - and describe how it represents a new model for these assessments to serve as tools to help instructors improve future courses.

(SUN-POS-N-PER507) | Poster Presentation Traditional | Redesigning Legacy Conceptual Inventories: Using Evidence Centered Design to Develop Valid, Equitable, and Flexible Items for Conceptual Understanding of Kinematics and Dynamics in Introductory Physics

Presenting Author: Rachel Henderson, Michigan State University

Additional Author | Dena Izadi, Michigan State University

Additional Author | John Stewart, West Virginia University

Additional Author | Gay Stewart, West Virginia University

Additional Author | Andrew Heckler, Ohio State University

Commonly used legacy instruments, such as the Force Concept Inventory (FCI), have shown some serious flaws including substantial psychometric problems and demographic biases which make them inaccurate for some underrepresented student populations. Even with these flaws, these instruments have been vital to the development of Physics Education Research (PER) as a discipline; however, while the teaching of physics has evolved, the formative assessments researchers, instructors and, more broadly, physics departments use to evaluate their classrooms have not. In this poster, we will discuss the project goals and development strategy of our new NSF award (#2235518) intended to design a set of valid, fair, and flexible tool assessing conceptual understanding of kinematics and dynamics for introductory physics courses. Constructed within Evidence Centered Design, the new assessment items will be grounded in learning and measurement theory, based on a construct-centered and community-based approach. The flexible instrument, the Kinematics and Dynamics Assessment, will include multiple scales measuring foundational topics within kinematics and dynamics organized into subscales which instructors can utilize to build their own classroom assessment. The library of items will be extensively validated to ensure superior psychometric properties and instrumental fairness for women, underrepresented minority students, and first-generation college students.

*This work is supported by the National Science Foundation (DUE-2235518, DUE-2235595, DUE-2235681).

(SUN-POS-N-PER509) | Poster Presentation Traditional | Initial Results in Evaluating Conscientiousness in Student Responses to Show-Work Exam Questions

Presenting Author: Heather Mei, The Ohio State University

Additional Author | Qiaoyi Liu, University of Colorado Boulder

Additional Author | Andrew Heckler, The Ohio State University

Conscientiousness can be an important factor in course performance that is often studied in the context of gender differences. Recent work has also documented that gender differences in performance can vary by specific graded components of the course. To better understand the relationship between gender, conscientiousness and performance on specific graded tasks, we have launched a project to analyze the level of conscientiousness of student responses to show-work exam questions in a calculus-based introductory physics course during the fall 2022 semester at a large public research university. We describe a coding scheme for "Show-Work Conscientiousness" (SWC), which include diagrams drawn, final answer markings, defined variables, straight lines, spacing, crossed out work, smudging, text elaboration, logic flow, photographic care, handwriting legibility, and holistic neatness. Further, we report on the inter-rater reliability and the Pearson correlation for all twelve dimensions of SWC. Finally, we present some preliminary results from the exploratory factor analysis to determine the underlying factors for SWC.

(SUN-POS-N-PER511) | Poster Presentation Traditional | Creating an Assessment Item to Elicit a Blend of Science and Mathematical Sensemaking for Students in Introductory Physics

Presenting Author: Sage Foster, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Students have many epistemological resources to use when encountering a complex problem. A framework we can use to understand how students approach such a task is a blend of science and mathematical (Sci-Math) sensemaking. While engaging students with Sci-Math sensemaking may be a goal in many introductory science courses, we have limited ways of assessing it directly. In this poster, we will discuss our efforts toward creating a physics task intended on eliciting students' Sci-Math sensemaking as a part of a larger multi-institutional and cross-disciplinary NSF award (DUE-2235487, DUE- 2235413, DUE-2235641, and DUE-2235311). Over the past year, we have leveraged the Three-Dimensional Learning Assessment Protocol, which includes core ideas, scientific practices, and cross-cutting concepts, and a modified version of Evidence Centered Design to develop an open-ended task centered around the core idea of Energy is Conserved. The task was given as an exam question in a calculus-based, introductory physics course. Here, we will present our development process as well as the Sci-Math themes from the students' responses.

*This work was supported by the National Science Foundation (DUE-2235487, DUE- 2235413, DUE-2235641, and DUE-2235311).

(SUN-POS-N-PER513) | Poster Presentation Traditional | Beyond the Normalized Gain: Conceptual Growth Curves

Presenting Author: Elaine Christman, West Virginia University

Co-presenting Author | Paul M. Miller, West Virginia University

Additional Author | John C. Stewart, West Virginia University

Although Hake developed normalized gain to facilitate the comparison of outcomes on conceptual evaluations across student populations with differing incoming physics knowledge, there is substantial evidence that it does not completely correct for differences in prior preparation. We found that neither the normalized gain nor Cohen's d corrected for semester-to-semester variation in pretest scores on the Force and Motion Conceptual Evaluation at our institution, and as such, was limited as a tool for comparison across instructors or instructional models. We propose a new representation of student-level data, which we call the Conceptual Growth Curve, that allows us to make use of the natural variation within our student population to evaluate the efficacy of instruction and make more meaningful comparisons with published research.

(SUN-POS-N-PER515) | Poster Presentation Traditional | Challenges and Difficulties in Collecting a Truly Representative Sample of IPLS Students for the FCE Development

Presenting Author: Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | DJ Wagner, Grove City College

Additional Author | James Vesenka, university of New England

Additional Author | Daniel Young, University of Deleware

Additional Author | Dawn Meredith, University of New Hampshire

To increase the likelihood of developing a fair, reliable, and valid standardized research-based conceptual learning assessment instrument, researchers must use a truly representative sample of the types of individuals for whom the instrument is designed to evaluate. Researchers developing the Fluids Conceptual Evaluation (FCE) decided to make every attempt to establish a truly representative sample population of post-secondary IPLS students for every stage in development. This involved the collection of data from a variety of different types of institutions and students from around the country. Taking over three years to obtain, the researchers faced many challenges along the way. This poster presents an overview of these challenges and how the researchers collected the data for this development process as well as suggestions for future conceptual learning assessment developers. Supported by NSF Award #, 2021273.

(SUN-POS-N-PER517) | Poster Presentation Traditional | Student Effort on Assessment Tests

Presenting Author: Michael Orleski, Misericordia University

Additional Author | Jeffrey Stephens, St. John Fisher University

Assessment in introductory physics courses often utilizes conceptual inventories. Often these inventories are given to students as a pretest and later as a posttest. The scores are then compared to gauge student learning. This study attempted to determine if the self-reported level of effort/seriousness that students applied to stand-alone assessment tests depended on receiving an extrinsic motivator i.e., extra credit.

(SUN-POS-N-PER519) | Poster Presentation Traditional | Discovering Misconceptions as Patterns of Wrong Answers on Multiple Choice Instruments

Presenting Author: David Pritchard, MIT

Co-presenting Author | Aaron R Adair, MIT

Additional Author | Martin Segado, MIT

Particular student misconceptions should result in associated patterns of wrong answers (distractors) on research-designed multiple choice instruments. We find misconceptions by using our Bayesian realization of the most general IRT model, the Multidimensional Nominal (normalized) Categories (choices per question) item response Models (MNCM (1)) to generate discriminations for each choice for each question. A non-orthogonal bi-quartamin rotation then emphasized only the "wrongest" distractors (most negative discrimination) for each dimension - these are the misconception patterns. On the FCI we found known misconceptions (Impetus, Circular Impetus, and Active or Larger Object Applies more Force) (2) and one new one: No Inertia (velocity immediately follows force). We find similar misconception patterns, but with more or less prevalence at different colleges. We also show the surprisingly small effect of "testing noise" by randomizing 5% of all student responses. Our code is available on git-hub and we are happy to share them.

(1) Revuelta, J. (2014). Multidimensional ítem response model for nominal variables. Applied Psychological Measurement, 38(7), 549–562

(2) Halloun, I. A., & Hestenes, D. (1998). Common sense concepts about motion, 1056(1985). http://doi.org/10.1119/1.14031

PER: Beyond Intro Posters I

(SUN-POS-M-PER401) I Poster Presentation Traditional I Exploring Experts' Reasoning Strategies in Proportionality Tasks

Presenting Author: Michele Lau, Rutgers University

Additional Author | Joe Olsen, Rutgers University

Additional Author | Charles Ruggieri, Rutgers University

This study examines the proportional reasoning strategies used by physics Ph.D. candidates in real-time by applying Carlson et al.'s (2002) mental action framework to the Ph.D. candidates' cognitive processes. The study conducted eight individual think-aloud interviews during which each participant solved eight separate proportional reasoning tasks. The interviews were recorded and segmented into a total of 64 clips for analysis, and each clip was analyzed using Carlson's framework. The research team found that while Carlson's framework is useful, it may not fully capture the nuances of experts' proportional reasoning strategies, highlighting the need for a more comprehensive approach to the study of covariational reasoning in physics education research.

(SUN-POS-M-PER403) I Poster Presentation Traditional I Exploring Retention Rates in Physics Graduate Programs

Presenting Author: Christopher Overton, UGA

Additional Author | Nicholas B Young, UGA

Graduate students and graduate degree holders play a central role in the growth of science and technology for both institutions and the country. They serve as researchers pursuing advances in science and educators preparing the next generation of scientists. Historically STEM graduate programs have had a low retention rate, potentially causing a high cost for both those leaving the programs and for society at large. In this talk we look at the past two decades of the American Institue of Physics' annual rosters with a focus on the number of graduate students in programs and the graduation rates for these students. By observing the trends over the past two decades, we can make general observation about the current state of graduate education in the United States. We find that while over the past 20 years the general trend has been towards an increase in graduate students in programs across the country as well as annual degrees earned. We find that there is variation in the retention rates of different programs. Our results can better inform prospective graduate students and faculty about current trends in the field of education and potentially inspire change.

(SUN-POS-M-PER407) I Poster Presentation Traditional I Investigating Student Perceptions of Creativity and Generative AI in Computational Physics

Presenting Author: Pachi Her, Oregon State University

Additional Author | Patti Hamerski, Oregon State University

Generative Artificial Intelligence (gen-AI) is rapidly becoming more integrated into today's classrooms in all ranges of education. In higher education, Gen-AI is often seen as a resource for students, aiding them in drafting outlines, solving simple mathematical problems, or even decoding or constructing code. In this paper, we analyze essay-based interviews (N=6) from an upper-division computational physics course, in which physics majors addressed their views and attitudes towards Gen-AI and how it affects their learning. We analyzed the concepts of creativity and gen-AI using the Four C Model, a framework encompassing four types of creativity. Our analysis of the data involved coding and characterizing students' definitions of creativity and generative AI. Our findings revealed two main observations: first, students conceptualized their creativity primarily within mini-c and little-c; second, students perceived gen-AI as a resource and learning tool but expressed skepticism regarding its accuracy and creativity.

(SUN-POS-M-PER409) I Poster Presentation Traditional I Physics Graduate Students' Perspectives on Oral Candidacy Exams

Presenting Author: Lilit Sargsyan, Rutgers University

Additional Author | Geraldine L. Cochran, Ohio State University

Physics graduate programs require students to pass a candidacy exam to change their status from a graduate student to a Ph.D. Candidate. The format and scope of candidacy exams differ from one department to the next. Literature on candidacy exams' purpose, format, and efficacy is scarce. Our study seeks to contribute to the literature on candidacy exams in physics. For that purpose, we developed a framework that will help to investigate graduate students' perspectives of oral candidacy exams. Our conceptual framework consists of 3 interconnected parts: physics identity, graduate student identity, and doctoral student development. Coded interview excerpts and initial data analysis results will be presented.

(SUN-POS-M-PER413) I Poster Presentation Traditional I Simplified Toy Models Can Make Physics Harder to Grasp

Presenting Author: Ebba Koerfer, Uppsala University

Additional Author | Bor Gregorcic, Uppsala University

Idealized models are a natural part of physics research and education. In upper-division physics courses, which tend to be more abstract and mathematically advanced than the introductory courses, such simplified toy models often serve as pedagogical tools to illustrate concepts and calculations. In the topic of statistical mechanics, we have studied the challenges faced by small problem-solving groups of upper-division students. Our findings indicate that students struggle to recognize the underlying structure of commonly used toy models. Students faced various pitfalls as they tended to rely on surface features of the tasks, in combination with loosely connected ideas about key concepts. Based on our findings, we discuss recommendations for teachers in statistical mechanics and other advanced courses that resort to simplified models to explain complex ideas.

(SUN-POS-M-PER415) | Poster Presentation Traditional | Developing a Separation of Variables Tutorial for Upper-division Physics Contexts

Presenting Author: Idris Malik, North Dakota State University

Additional Author | Warren M Christensen, North Dakota State University

Additional Author | Matthew K Hansen, North Dakota State University

Undergraduate physics students are often taught and retaught mathematical methods in multiple courses in multiple ways, but may still not be prepared to transfer those methods to new contexts. Here, we sought to develop a tutorial for students to learn how physicists approach the strategy of "Separation of Variables" for solving second-order partial differential equations. Students create and revise their own list of steps for the Separation of Variables procedure while working through the tutorial. We produced versions with different orderings of a Quantum Mechanics, Electricity and Magnetism, and Heat Equation example, all with a gradual reduction of scaffolding between these examples. We intend that these different versions of this tutorial can be used in a Math Methods course, or an upper-division E&M or Quantum Mechanics course. We elicited feedback from undergraduate students, graduate students, and Math and Physics faculty when producing these tutorials, and piloted it in an undergraduate E&M class. One unique aim of this tutorial is to include a focused amount of content without requiring extensive background knowledge, in contrast to some existing tutorial/explanation sections of textbooks. We hope that this tutorial and surrounding research will help us better support students who will use mathematical methods in physics courses.

Material based on work supported by NSF PHY 1912152. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.

(SUN-POS-M-PER417) | Poster Presentation Traditional | Peer interaction facilitates co-construction of knowledge related to quantum mechanics formalism and postulates

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | Alysa Malespina, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Collaborative learning with peers can lead to students learning from each other and solving physics problems correctly not only in situations in which one student knows how to solve the problems but also when none of the students can solve the problems alone. In the latter situation, students are co-constructing knowledge that helps them solve the problems, while in the former, one student helps the other construct knowledge. In this study, we investigated student learning measured by student performance on a validated quantum mechanics survey and frequencies of construction and co-construction of knowledge when students first worked individually after lecture-based instruction in relevant concepts and then worked with peers during class without receiving any feedback from the course instructor. We find that the construction of knowledge consistently occurred at a high rate during peer collaboration. However, rates of co-construction were more varied.

PER: DEI Posters I

(SUN-POS-L-PER301) | Poster Presentation Traditional | The Landscape of Physics Education: Recent Classroom Examples from PER Literature and Our Own, with Historical Experiments, Story-Telling, Feminism and Indigenous Experience

Presenting Author: Elizabeth Cavicchi, Edgerton Center, MIT

Additional Author | Riley Moeykens, MIT

Additional Author | Hillary Diane Andales, University of Chicago

We reviewed Physics Education Research (PER) literature, identifying studies where physics students engage with physics in wider contexts (International Handbook of Physics Education Research, AIP, 2023, III, chapter 13). Our review demonstrates spread in how context, student participation; and knowledge function in researchers' classrooms: from those transmitting pre-specified information, to those accommodating student activities, to physics students having agency in investigating contexts that matter to them. This poster's central illustration depicts that spread metaphorically as the Landscape of Physics Education. Mountain peaks denote decontextualized hierarchical instruction. Water represents contextualizing efforts. Scarce up high, descending water erodes barriers to context. Low elevations are fluid: students' identities are celebrated; teachers facilitate students' questioning. This poster features PER studies from multiple elevations. Examples include: physics students use electromagnetic instruments in Lorentz's original lab (Spek 2021); Brazilian students question funding's impact on science (Jardim et al., 2021; Greek children create animated films (Piliouras et al., 2011); indigenous Canadian children explore sound while making ceremonial drums (Metz 2017); German students interview queer and female physicists (Lucht, 2021). These studies inspire us. Our students express identity through collage. A retired engineer joined our class on zoom, sharing mutual experiences. We encourage physics teachers to creatively invite context into low elevation experiences.

(SUN-POS-L-PER303) | Poster Presentation Traditional | Social Positioning Correlates with Consensus Building in Two Contentious Board Meetings

Presenting Author: brant hinrichs, drury university

Additional Author | david brooks, california state chico

Additional Author | jacob nass

This poster analyzes two examples of whiteboard meetings from a college calculus-based introductory physics course taught using University Modeling Instruction. In UMI, student small groups create a solution to the same problem on 2' × 3' whiteboards. They then sit in a large circle with whiteboards held facing in and conduct a student-led whole-class discussion to reach consensus. In the first example students overcame sharp disagreements to reach consensus, but in the second example they don't. We examine how social positioning contributed to students either successfully examining and resolving different ideas or failing to do so. Results from these two examples support the idea that meetings where "experts" soften their position by "hedging" more frequently are better able to overcome sharp initial disagreements to reach consensus on their own. Our analysis suggests that the way students position themselves in discussions may open or close the collaborative space to productive sense-making.

(SUN-POS-L-PER305) | Poster Presentation Traditional | Longitudinal Analysis of Who Repeats Introductory Calculus-based Physics Courses by Ethnicity/Race

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Ly Malespina, University of Pittsburgh

Additional Author | Yangqiuting Li, Auburn University

Additional Author | Chandralekha Singh, University of Pittsburgh

We analyze institutional data from large introductory calculus-based physics courses at a large predominantly White public research university in which most students are engineering majors with some chemistry, physics and mathematics majors. Introductory physics courses can act as a gatekeeper for many students, particularly those who come from marginalized backgrounds such as ethnic and racial minority (ERM) students. Many students who do not perform to their satisfaction the first time choose to repeat the course, particularly if they aspire to remain in their major. We present an investigation in which we analyze the performance of students from different demographic groups who repeated the first introductory calculus-based physics course. These findings can be beneficial to contemplate strategies for creating equitable and inclusive learning environments and providing support to help all students excel in calculus-based physics courses which are pivotal for accomplishing the long-term career goals of many students.

(SUN-POS-L-PER307) | Poster Presentation Traditional | Impacts of a Male Dominated Physics Environment on Undergraduate Women

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

This research focuses on the experiences of three undergraduate women who are physics majors. Specifically, we conducted semi-structured, empathetic interviews which reveal how uncomfortable physics environments inside and outside of the classroom exclude undergraduate women. The women give accounts of the behaviors of their male peers and instructors that influenced the physics culture. We use standpoint theory to focus on the experiences of undergraduate women to provide a holistic perspective of physics as well as identify key issues that these women faced in their undergraduate physics program and potential strategies to implement in the future to support undergraduate women in physics. Some of their suggestions include providing mentoring for women, training sessions, and establishing a code of conduct.

(SUN-POS-L-PER309) | Poster Presentation Traditional | Improving Access in Group-based Courses for students with ADHD

Presenting Author: Daryl McPadden, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Harsna Chahal, Michigan State University

Additional Author | Alex Reynolds, Michigan State University

Over the last several decades, active learning has been incorporated into many physics courses, often requiring students to work in groups on problem solving. While active learning has been shown to be beneficial for students on average (in conceptual understanding, attitudes, self-efficacy), very few studies have examined the experiences of disabled students in active learning courses. In this work, we present a case study focused on the experiences of three students with ADHD and their experiences in group-based STEM courses. From a series of four interviews with the participants, we highlight the course structures and relationships that had an impact on these students. From these results, we make recommendations to instructors and course designers for strategies to improve access in their classrooms.

(SUN-POS-L-PER311) | Poster Presentation Traditional | Looking at How Student's Use Their Cultural Resources to Understand Physics

Presenting Author: Andrea Wooley, Michigan State University

Co-presenting Author | Clausell Mathis, Michigan State University

The framework of culturally relevant pedagogy has helped instructors transform their physics classrooms by including student culture in their instruction. Our study aims to support this transformation by identifying the ways in which students utilize their cultural resources to learn physics, as an indication of their engagement with CRP instruction. We analyze written responses to the conceptual physics questions from students in an introductory physics class at a Historically Black College & University (HBCU). The analysis of students' responses aims to identify their use of cultural resources and their demonstration of canonical physics knowledge, serving as indicators of student activation of cultural resources to learn physics. We find that students use cultural resources by building on their prior knowledge and experiences, writing stories about their personal experiences, and using their home language practices.

(SUN-POS-L-PER313) | Poster Presentation Traditional | Students' Perceived Recognition from Instructors Can Impact Students' Self-efficacy and Interest in Physics

Presenting Author: Yangqiuting Li, Oregon State University

Additional Author | Chandralekha Singh, University of Pittsburgh

In this study, we analyzed data from individual interviews with 38 female students to investigate their learning experiences in physics courses to obtain a qualitative understanding of the factors that shape their self-efficacy and interest. The results reveal that many interviewed women experienced negative perceived recognition or lack of positive recognition from their physics instructors or teaching assistants (TAs), which fell into three categories: feeling belittled for questions or efforts, feeling negatively recognized regarding abilities and potential, and feeling marginalized due to differential gender dynamics. In contrast, only a few interviewed women reported positive perceived recognition from instructors or TAs, which included recognition of abilities, encouragement to pursue goals, and acknowledgment of the normality of struggles. We find that positive perceived recognition enhanced students' self-efficacy and interest, while negative perceived recognition or lack of positive recognition undermined them. These findings provide valuable insights for physics educators to improve their interactions with students by providing positive recognition and validation. Our research also suggests that it is important for instructors or TAs to internalize that it is not their intentions that matter but the impact they are having on their students.

PER: Intro Posters I

(SUN-POS-K-PER201) | Poster Presentation Traditional | Effect of Wakeful Rest on Recall and Conceptual Understanding in Physics

Presenting Author: Anna Mederer, Worcester Polytechnic Institute

Additional Author | Andrew A. McReynolds, Worcester Polytechnic Institute

Additional Author | Stacy T. Shaw, Worcester Polytechnic Institute

Additional Author | Benjamin Pollard, Worcester Polytechnic Institute

Introductory physics courses cover a wide range of conceptually and mathematically challenging content that students often find difficult to understand and remember. Therefore, it is important for physics educators to help students integrate and retain new information into mental schemas. One possible strategy is to insert wakeful rest at the end of a lecture. Wakeful rest is an activity where one is sitting with their eyes closed so there is minimal visual and auditory stimulation. Wakeful rest has been shown to improve memory consolidation but has not been studied in a classroom setting. The goal of this study is to determine whether wakeful rest benefits memory consolidation and recall of course material in an undergraduate introductory physics course. Participants either spent 10 minutes at the end of lecture engaging in wakeful rest or left class early. We will present preliminary results on the impact of wakeful rest on students' recall and understanding of physics concepts.

(SUN-POS-K-PER205) | Poster Presentation Traditional | Exploring Student Reasoning about Circuits uUsing Reasoning Chain Construction Tasks

Presenting Author: Vincent Doan, University of North Florida

Additional Author | J. Caleb Speirs, University of North Floridae

Physics education research has a long tradition of analyzing and supporting student conceptual understanding of specific physics topics, with electric circuits being no exception. This research seeks to explore a new methodology for how students formally reason with circuits concepts. This new methodology places emphasis on the process of linking concepts and observations together into a logical chain of reasoning using reasoning chain construction tasks, previously reported on in the literature. Additionally, this study builds upon previous research on students' comprehension of circuits and aims to explore how reasoning chain construction tasks can help illuminate students' use of conceptual ideas before and after receiving instruction. As such, this research contributes to the broader field of physics education by offering additional insight into student reasoning patterns, providing educators and researchers with more tools to inform instructional strategies and curriculum design in electric circuits education.

(SUN-POS-K-PER207) | Poster Presentation Traditional | A Peer Mentorship Intervention in First-Year Physics During the COVID-19 Pandemic

Presenting Author: Edmund Bertschinger, Massachusetts Institute of Technology

The interruption of classes mid-semester in March, 2020 by the COVID-19 pandemic provided the opportunity for a natural experiment on the efficacy of peer mentoring to support learning in a large first-year physics class. Once classes resumed, eighty-eight students in the class met weekly one-on-one for up to an hour with trained mentors (mostly more advanced undergraduates who were paid for their efforts, but also including some staff and faculty) for both academic and psychosocial support. Mentees showed greater learning gains than non-mentees. Students who scored low on the pre-pandemic midterm and who participated as mentees showed the greatest improvement. In addition, students who undertook mentoring showed evidence of increased effort relative to those who did not participate. Structural equation modeling is used to estimate the contributions of preparation (via the pre-mentoring midterm exam), effort, and the mentorship intervention on learning gains. Surveys of mentee and mentors as well as interviews of mentors were used to identify program elements that foster belonging, STEM identity, and self-efficacy in both mentees and mentors.

(SUN-POS-K-PER209) | Poster Presentation Traditional | Development of a Scale to Measure Self-regulated Learning Behaviors in an Introductory Physics Course: A Confirmatory Factor Analysis

Presenting Author: Danielle Maldonado, West Virginia University

Additional Author | John Stewart, West Virginia University

This poster will detail the process of developing an instrument to measure self-regulated learning behaviors in a college calculus-based introductory physics course. Students were encouraged to evaluate the extent to which they exhibited certain self-regulated learning behaviors in preparation for course exams, with four surveys offered throughout the semester. The behavior questionnaire was developed using items from the Motivated Strategies for Learning Questionnaire (MLSQ) and the Metacognitive Awareness Inventory (MAI). A 5-factor model was proposed to measure student behaviors toward Planning, Time and Study Environment, Comprehension Monitoring, Peer Learning and Help-Seeking, and Evaluation. Exploratory factor analysis and confirmatory factor analysis suggested that a 3-factor model was more appropriate and that there was considerable correlation between the Planning, Comprehension Monitoring, and Evaluation constructs.

(SUN-POS-K-PER211) | Poster Presentation Traditional | Text Mining for Analyzing Student Survey Text Responses: A Case Study in Introductory Physics for Life Sciences

Presenting Author: Mayuri Gilhooly, Rockhurst University

This poster presents a way to analyze text responses from student attitude surveys in an Introductory Physics for Life Sciences course. Leveraging sentiment analysis techniques, including Valence Aware Dictionary for sEntiment Reasoning (VADER) and Affective Norms for English Words (AFINN), the study categorizes student responses into positive, neutral, and negative sentiments using Python. A comparative analysis between VADER and AFINN methods is provided. Additionally, topic modeling is employed to uncover underlying themes within the text data, offering educators valuable insights into student perceptions. The proposed methodology aims to expedite the identification of negative sentiments and facilitate targeted interventions to address student concerns.

TYC Posters I

(SUN-POS-B-201) | Poster Presentation Traditional | A Revision of Guidelines for Two-Year College Physics Programs

Presenting Author: Keith Madden, Ivy Tech Community College

The last revision of the Guidelines (1) occurred in 2002. Recent advances in physics education research have shown the need for a major update. Under the auspices of the Organization for Physics at Two Year Colleges, a committee was assembled to update criteria for curriculum (in-seat and remote), laboratory instruction, necessary support personnel, budgets, and physical plant. In the process, we have assembled an extensive library of peer-reviewed literature supporting changes in methods and facilities needed to support student success in the two-year college environment. We are incorporating those ideas into our first draft of the revised document. We will report the status of our efforts on this poster.

1. Hogan, W.; Davies, C.; O'Kuma, T.; Plumb, M.; Waggoner, W.; Warren, W.; Guidelines for Two-Year College Physics Programs AAPT (2002)

(SUN-POS-B-203) | Poster Presentation Traditional | Continuing Professional Development Workshop Program – Year 2 and Beyond

Presenting Author: Thomas O'Kuma, Lee College

Co-presenting Author | Paul J. Heafner, Independent Scholar

Co-presenting Author | Kristine P. H. Lui, OPTYCs / AAPT

OPTYCs is The Organization for Physics at Two-Year Colleges (https://optycs.aapt.org). Part of the OPTYCs mission is to provide Continuing Professional Development Workshops (CPDW) and Tandem Meetings for TYC physics faculty across the country. In this poster, we will summarize the workshops and the Tandem Meeting that occurred during year 2 of the project. We will also highlight workshops at the current meeting and any currently scheduled future workshops and the 2025 Tandem Meeting. We will also invite TYC physics colleagues and others to submit ideas for workshop content (https://optycs.aapt.org/user/Contact.cfm). CPDW is open to all with an emphasis for TYC faculty. OPTYCs is supported by NSF-DUE-2212807.

(SUN-POS-B-205) | Poster Presentation Traditional | "Doing Physics" at an HSI Community College – The SPARC Model

Presenting Author: Yoel Rodríguez, Hostos Community College of CUNY

Additional Author | Antonios Varelas, Hostos Community College of CUNY

Co-presenting Author | Anna Ivanova, Hostos Community College of CUNY

Additional Author | Anthony L. DePass, DePass Academic Consulting

Challenges when studying physics, especially for those prepared at under-resourced schools, create feelings of discomfort and lack of self-efficacy approaching this subject matter. These issues contribute to students not considering STEM degrees and careers. Thus, we have created the NSF IUSE funded SPARC – Strengthening Physics Achievement via Research and Collaboration Project whose goal is to improve undergraduate student outcomes in a calculus-based General Physics I course and prepare them for subsequent science and engineering curricula. Here we present our "Doing Physics" (DP) intervention that emphasizes problem-solving, scientific reasoning, and collaborative skills. DP employs inquiry-based science, Course-based Undergraduate Research Experiences-CUREs, mentored research, and game-based learning. Results indicate that SPARC has improved the average course pass rate of General Physics from 48% to 58% in Spring 2023, the first year of implementation. SPARC has the potential to improve undergraduate Physics education and to be expanded to other STEM courses and colleges.

(SUN-POS-B-207) | Poster Presentation Traditional | Using Leadership Skills in the Redesign of a TYC Astronomy Program: An OPTYCS Leadership Institute Project

Presenting Author: Matthew Pappas, Suffolk County Community College

On January 6, 2024, the OPTYCS Leadership Institute met in New Orleans for a day-long program where participants learned to identify and hone their leadership strengths. The program culminated with individuals designing a professionally focused project they could apply these leadership skills. As a participant, the project I developed was to explore avenues to enhance the newly revamped astronomy program at Suffolk County (NY) Community College and to use my leadership skills to grow the program. Efforts have been made to identify and survey the important stakeholders in the program, inventory departmental and college-based resources, and coordinate public outreach efforts, all with the goal to establish a larger cohort of astronomy majors enrolling prior to their first semester at the college. The status of these efforts are presented within the framework of the leadership skills developed through the Leadership Institute.

SUN-POS-B-209) | Poster Presentation Traditional | Two-Year Colleges' DEI Efforts: Instructor Actions from an OPTYCs Program

Presenting Author: Abigail Daane, South Seattle College

Additional Author | Kristine Lui, AAPT

Additional Author | Sherry Savrda, AAPT

Additional Author | Dwain Desbien, Estrella Mountain Community College

Additional Author | Kristine Washburn, Everett Community College

Additional Author | Chitra Solomonson, Greenriver Community College

What do you get when you put 11 instructors in a room for a two-day immersive discussion that centers students in DEI-effective practices? A lot of amazing actions to share! In this presentation, we will first give an overview of the DEI Capacity-Building Program organized by OPTYCs, The Organization for Physics at Two-Year Colleges. Participants in the first cohort of this two-year program have already begun work towards shifting practices to increase DEI in their classrooms. We share some highlights of their work that came out of the two-day retreat in January 2024 and how that work has continued together during virtual follow-up meetings. A second cohort will begin next year. Applications for this program will open summer 2024, and all interested two-year college faculty who teach physics-related courses are invited to apply. OPTYCs, including this program, is supported by the National Science Foundation under Grant No. 2212807

(SUN-POS-B-211) | Poster Presentation Traditional | Bridging the Gap: Data-Driven Insights for Equitable Physics Instruction

Presenting Author: Chloe Elise Hennessy, South Seattle College

Additional Author | Elizabeth A. Schoene, South Seattle College

Additional Author | Abigail R. Daane, South Seattle College

Within STEM, physics ranks among the least aligned with the US population regarding racial and gender representation. This not only has the potential to hinder new discoveries and innovations, it also highlights a lack of equitable opportunities for individuals. In an effort to identify ways in which teaching practices may contribute to this problem, our research explores correlations between active learning strategies and growth in students' conceptual understanding. The data analyzed are from a pre/post survey in a two-year college calculus-based introductory university physics class with a primarily Vietnamese, Black, and white population. We present topics including force and free-fall that show either substantial or limited improvement in student learning gains. We compare data across several demographics, and relate corresponding learning activities. We provide recommendations to improve both learning outcomes and instructional methods, with the aim of increasing opportunities for all identities to complete degrees and pursue career goals.

Session AA: Much More Than ChatGPT – AI tools for Learning and Teaching I

Location: Harbor Level, Harbor I **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Jochen Kuhn

(AA-01 9:00 AM-9:24 AM) | | Opportunities and Challenges of Generative AI in Physics Education

Presenting Author: Stefan Küchemann, Ludwig-Maximilians-University Munich

Additional Author | Karina Avila, Ludwig-Maximilians-University Munich

Additional Author | Yavuz Dinc, Ludwig-Maximilians-University Munich

Additional Author | Natalia Revenga, Ludwig-Maximilians-University Munich

Additional Author | Chiara Hortmann, Ludwig-Maximilians-University Munich

Additional Author | Niklas Stausberg, Ludwig-Maximilians-University Munich

Large language models (LLMs) like ChatGPT have shown significant potential in education. Recent studies also demonstrate and discuss the potential of these models in physics education. However, the integration of LLMs in physics classrooms is not straightforward, and there are several concerns such as negative impact on learning willingness, exam fraud and misuse. Therefore, it is essential to create empirical evidence on effective opportunities of LLMs in physics education. In this presentation, we will discuss opportunities and challenges of LLMs in physics education based on prior research. Specifically, we will report on both opportunities and associated challenges of LLMs in physics for the students as well as for teachers. First, we will demonstrate how prospective physics teachers use ChatGPT to create physics tasks in comparison to a control group that used a physics textbook. The results show that prospective physics teachers who use a textbook more often embedded the tasks into a meaningful context, but both groups often forget to include key information in the tasks. In this line, we will demonstrate evidence on the reliability and validity of the output of LLMs and outline avenues for effective learning support for students in physics.

(AA-02 9:24 AM-9:48 AM) | | Enhancing Quantum Technology Education Through Gamified and AI Cooperative Learning

Presenting Author: Karina Avila, Ludwig-Maximilians-Universität München

Additional Author | Jochen Kuhn, Ludwig-Maximilians-Universität München

Additional Author | Stefan Küchemann , Ludwig-Maximilians-Universität München

This project aims at leveraging gamification and artificial intelligence (AI) to teach complex and abstract concepts of second-generation quantum technologies (QT). Our primary goal is to create an adaptive smartphone game, augmented with virtual reality (VR) features, that introduces players to the fundamental principles of quantum physics and their applications across various technological domains. In this presentation, we introduce our approach, which is rooted in educational research and emphasizes the benefits of interactive and personalized learning experiences in promoting understanding and retention. One particular aspect of our game is the incorporation of an AI-based virtual character. This character facilitates a cooperative learning environment and cultivates collaborative problem-solving skills, a crucial competency in 21st-century education. The project aims to lower the entry barriers for learning about QT, enhance awareness and understanding of quantum phenomena, and by providing a hands-on, immersive learning experience, it aspires to spark interest and curiosity in QT among students and the broader public.

Session AB: Labs and Apparatus: Introductory Labs I

Location: Harbor Level, Harbor II **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Virginia Card

(AB-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Credit analysis of Physics courses at the Aerospace Engineering and Industrial Design School (ETSIADI), Universitat Politècnica de València (UPV), Spain.

Presenting Author: Juan Carlos Castro-Palacio, Universitat Politècnica de València

Additional Author | Luisberis Velázquez, Universidad Católica de Norte

Additional Author | Boris Atenas, Universidad Católica de Norte

Additional Author | Juan Antonio Monsoriu, Universitat Politècnica de València

In this work we make a credit and student workload analysis in the Physics courses at the ETSIADI, UPV. For this purpose, we developed an adaptive methodology for the curricular redesign based on the performance indicators of the student progression observed after a follow-up period of 20 years (2003-2023). The results show the complex adaptive character of the academic environment which exhibits regularities similar to those found in financial markets (e.g., distributions of the daily time devoted to learning activities follow patterns like Pareto's or Zipf's law). Our empirical results show the relevance of economic notions in the understanding of the teaching–learning processes and the reliability of quantitative methods based on student's academic performance to conduct experimental studies. We introduce a series of indicators which are also capable of characterizing both the professors' performance and the students' follow-up of the course.

(AB-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Development of Instructional Activities Using PhET Simulations with Noise to Promote Student Learning of Measurement Uncertainty

Presenting Author: Qiaoyi Liu, University of Colorado Boulder

Additional Author | Gayle Geschwind, University of Colorado Boulder

Additional Author | Heather Lewandowski, University of Colorado Boulder

Understanding concepts of measurement uncertainty is a core competency of physicists and engineers, and many physics lab courses aim to have students learn these ideas. However, there is strong evidence that these goals are often not met. To address the challenge of improving students' conceptual knowledge of measurement uncertainty, we developed simulations with adjustable noise and studied the impact of their use on student understanding of measurement uncertainty. Specifically, we added statistical noise to a selection of PhET simulations, and integrated them with the Common Online Data Analysis Platform (CODAP). Additionally, we developed relevant instructional activities for instructors to use in their lab courses. Finally, individual student think-aloud interviews were conducted with students working through the instructional activities. This presentation will describe the design of the new, specially-designed PhET simulations, along with their associated instructional activities, and report the results from the student think-aloud interviews. *This research was primarily supported by NSF DUE-2142356.

(AB-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Audible "Light Bulbs" to Make Circuit Labs More Accessible for Blind & Visually Impaired Students

Presenting Author: Dean Stocker, University of Cincinnati Blue Ash College

Additional Author | Karen Mayumi Chinchihualpa Paredes, University of Cincinnati

We are investigating the suitability of various electronic components that could be used as drop-in replacements for light bulbs in introductory circuit labs. We initially tried to use active buzzers or computer fans, which have been used successfully by others. The fans have relatively high turn-on voltages, so we would need to re-design our lab procedures to be able to use them. The buzzers we have managed to source have all been too loud for use in a classroom environment. We have breadboarded a relatively simple circuit based around an xx555 timer that appears to be promising as a drop-in replacement for a light bulb in our labs. The response of the circuit is ohmic, and it produces a pitch that varies with input voltage or current. The operational voltage range and both the volume and the frequency of the sound are adjustable by changing resistors or using variable resistors.

Session AC: ICEP = PICUP + ALPhA: Experiment & Computation Together

Location: Harbor Level, Harbor III **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Larry Engelhardt

(AC-01 9:00 AM-9:24 AM) | | Combining Theory, Experiment, and Computation in Undergraduate Lab Courses

Presenting Author: Todd Zimmerman, University of Wisconsin - Stout

To prepare our students for life after college, we need to provide them with an authentic experience of what research is like. As outlined by the ICEP workshop, this must combine theory, experiment, and computation. I will discuss a freshman-level and and a senior-level lab course that combines theory, experiment, and computation. Many of the activities are drawn from ALPhA and PICUP. I will discuss what these courses look like, what some of the hurdles have been, and what some of the success have looked like.

(AC-02 9:24 AM-9:48 AM) | | Computational Modeling of Electronic Modeling of Mechanical Chaos

Presenting Author: Eric Ayars, California State University, Chico

Chaotic behavior comes naturally to many of our students... But seriously, students enjoy studying nonlinear behavior in both experimental and computational lab work as it allows them to work on accessible physics problems that still generate interesting results. Mechanical systems such as the rotating magnetic dipole in an oscillating magnetic field and the driven damped pendulum are readily available from commercial equipment companies and even ALPhA Immersions, but these are 'slow' devices and data collection can be a very long process. Electronic chaotic oscillators such as the Kiers Circuit and others allow fast collection of precise data, but they lack obvious connection to the `real world'. I will present two chaotic circuits that closely model mechanical systems. Students can conceptually understand the mapping between the mechanical system and the circuit, can collect high-quality data in hours rather than in weeks, and can build computational models that exhibit the same behaviors as the circuits.

Session AD: 21st Century Astronomy and Physics in the Classroom I

Location: Lobby Level - Marina Ballroom II **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Peggy Norris

(AD-01 9:00 AM-9:24 AM) | | Several Ways to Introduce Particle Physics to Undergraduates

Presenting Author: Cindy Schwarz, Vassar College

Co-presenting Author | Olivia Trader, Vassar College

I started introducing students (initially those not studying physics) to "The Subatomic Zoo" over 30 years ago. Over many iterations of the course, students created stories, poems and even plays as final projects, based on what they learned about subatomic physics. More recently, I started working with physics majors on independent studies/projects where they used the particle chart (and other charts) from CPEP resulting in amazing videos where students detailed their own investigations and learning. During the spring of 2024, I worked with a first-year student who wanted to learn about high energy physics. In this talk I will review some of the past projects/ideas and then Olivia will explain more about her project; where she focused on explaining musical compositions from prior students as well as other ideas.

(AD-02 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Update on QuarkNet Data Activities Portfolio

Presenting Author: Deborah Roudebush, QuarkNet

The QuarkNet Data Activities Portfolio is a compendium of over 40 activities designed to assist teachers in incorporating 21st Century physics topics into the high school physics curriculum. The activities are searchable using filters based on level of challenge, curriculum topic, and NGSS standards. The talk will include examples from the portfolio that can form a chain of activities that build content knowledge and analysis skills.

(AD-03 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Introducing Particle Identification to Algebra-Based Physics Students

Presenting Author: Richard Dube, University of Connecticut

Additional Author | Diego Valente, University of Connecticut

Additional Author | Richard Jones, University of Connecticut

Although particle physics research is typically reserved for advanced undergraduates, algebra-based physics students can readily develop the foundational skills necessary to conduct particle physics research. Despite this, there is a shortage of educational resources that introduce particle physics to algebra-based physics students. Particle Identification Playground is a collection of Python-based activities that teach students about the first stage of particle physics data analysis, called particle identification, along with the working mechanisms of common particle detectors. In this talk, I will describe the motivation for Particle Identification (PID) Playground and highlight how it will enhance the ability of high-school and early undergraduate students to engage with particle physics research.

*Visit Particle Identification Playground here: https://duberii.github.io/pid-playground/

Session AE: Sex and Gender and Teaching and Research

Location: Lobby Level - Marina Ballroom III **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Sarah Johnson

(AE-01 9:00 AM-9:24 AM) | | Allyship Identities and Actions of Professors

Presenting Author: Jennifer Blue, Miami University

Additional Author | Ellison Brennan, Miami University

In a pilot survey of faculty at our university, almost all of them said that they were allies to the queer community. In that same study, several queer students told us that they had classmates who had said offensive things to them, and a few had faculty who had made them feel uncomfortable. We found ourselves wondering what it meant for a professor to call themselves an ally – so we have a new survey. Professors were asked about their familiarity with several terms used by LGBTQIA+ people. Faculty were asked whether they were allies, and then were asked nearly 20 questions about specific actions that allies might take. What do they actually do to show that they are allies?

(AE-02 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Predicting Retention of Women in Physics with Machine Learning

Presenting Author: Maxwell Franklin, Drexel University

Eric Brewe, Drexel University

In this work, we use a variety of machine learning tools to predict retention of women in physics. Previously, we used data collected at the Conference for Undergraduate Women in Physics, along with a follow-up survey, to study which factors correlated with long term persistence in physics. The factors we studied were sense of belonging, sense of community, interest, physics identity, perceived recognition, and performance competence. In this study, we build on our previous results by comparing the machine learning methods of support vector machines, neural networks, random forests, and logistic regression to best predict which women are most at risk of leaving the discipline. The end goal of this study is a tool that can effectively predict whether an undergraduate woman may need more support to remain in physics. Using this, professors could provide targeted interventions to increase overall retention, supporting gender equity in physics. Though we focus on gender equity in this work, the principles of our machine learning approach can be used for other predictive measures in physics education. This work aims to highlight the uses of each machine learning technique for other potential work.

(AE-03 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Combating Gender Bias on Wikipedia as a Lab Assignment

Presenting Author: Andrew Seredinski, Wentworth Institute of Technology

The systemic issues around bias and exclusion that physics must grapple with are mirrored online. One way to engage students in combating gender bias in physics is through Wikipedia editing. Overall, fewer than 1 in 5 biography articles on Wikipedia is about a woman. While the nonprofit Wiki Education provides robust resources for instructors looking to adapt a term paper into a Wikipedia assignment, this may be a poor fit for many physics courses (especially at the introductory level). I present piloted methods and results from a two-hour lab activity in which introductory-level physics students research and contribute to Wikipedia articles about notable women in physics.

Session AF: PER: Beyond Intro I

Location: Lobby Level - Marina Ballroom IV **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Cristian Bahrim

(AF-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Designing and Testing Upper-division Electromagnetism Tutorials

Presenting Author: James Hecht, Department of Physics and Astronomy, Brigham Young University

Additional Author | Dorian Baldwin-Bott, Department of Physics and Astronomy, Brigham Young University

Additional Author | David W. Neilsen, Department of Physics and Astronomy, Brigham Young University

Additional Author | John S. Colton, Department of Physics and Astronomy, Brigham Young University

Additional Author | Andrew J. Mason, Department of Physics and Astronomy, University of Central Arkansas

Currently we are investigating the effect of a sustained, semester-long system of tutorial development to address both the concerns of investigating a more thorough problem-solving framework at the upper-division level, and the effect of flexible tutorial design that is compatible with the instructor's course design and intended instructional methods. We investigate the effect of a set of tutorials designed in this way for a first-semester electromagnetism course at a large private Mountain West university during the Fall 2023 semester. Data analyzed includes qualitative interview from student participant focus groups and from post-tutorial self-assessments. Preliminary findings include students' perceived benefits and disadvantages of the tutorials, both in terms of scaffolding related to a problem-solving framework and in terms of the benefits of the in-class collaborative format.

(AF-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Impact Over Intent: Centering Student Experiences in Computationally Integrated Physics Courses

Presenting Author: Sarah McHale, University of Minnesota - Twin Cities

Additional Author | Shaul Hanany, University of Minnesota - Twin Cities

Additional Author | Ken Heller, University of Minnesota - Twin Cities

Additional Author | T.W. Jones, University of Minnesota - Twin Cities

Additional Author | Joseph Kapusta, University of Minnesota - Twin Cities

The School of Physics and Astronomy at the University – Twin Cities, is integrating computation into all physics major courses. As part of this process, the Physics Education Research group at UMN is investigating how undergraduate students of different identities experience these computationally integrated courses. This talk centers the impact of course changes by focusing on preliminary findings from ethnographic observations and interviews with students enrolled in the first upper-level courses to undergo computational integration. The course instructors' intent will be characterized by interviews with respective course professors and TAs. In bringing together instructor framings of physics computational literacy and student perceptions thereof, this talk will discuss the role that curricular decisions have on the development of students' computational literacy and physics identities.

*This material is based upon work supported by the National Science Foundation under Grant Nos. 2237827 and 2236244. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

(AF-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Investigating the Impact of Card Stacks in Upper Division Electricity and Magnetism

Presenting Author: J. Toby Stuckey, San Jose State University

Additional Author | Gina M Quan, San Jose State University

In this project, we investigate methods of helping students to improve their conceptual understanding in upper division electricity and magnetism (E&M). Students in this study fell under two categories: those who had taken E&M and those who were currently enrolled in the relevant course. Those who had taken E&M were interviewed and asked to perform conceptual analysis on vector field divergence and curl to identify potential difficulties some may have during the course. Those currently enrolled in the course participated in a filmed group activity, where students were asked to match cards representing vector field equations to field plots. Using this data, we identify challenges faced by students and analyze their thought processes when tackling such problems and seek to understand ways students can resolve mathematical formulation and physical intuition.

(AF-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | A Comparative Study of the Treatment of Electrostatics in Graduate Electromagnetism Textbooks

Presenting Author: William Newton, Texas A&M University-Commerce

Electromagnetism is considered by students to be one of the most challenging subjects at the graduate level, in part due to students' experience of Electromagnetism textbooks. The tone for the course is set by the first subject encountered in most textbooks, electrostatics. In this talk I will present an exploratory comparison of the pedagogical strategies employed by three graduate electromagnetism textbooks during the opening electrostatics chapters, with particular attention paid on the emphasis placed on conceptual physical and mathematical concepts in example problems and end-of-chapter problems.

(AF-05 9:48 AM-10:00 AM) | Contributed Talk (12 Minutes) | Research-based Instructional Strategies in Second-Year Physics Education: The Perspective of The Students

Presenting Author: Yessi Affriyenni, The University of New South Wales, Sydney

Additional Author | Christine Lindstrøm, The University of New South Wales, Sydney

Additional Author | Adam Micolich, The University of New South Wales, Sydney

Additional Author | Helen Georgiou, The University of Wollongong

The implementation of Research-Based Instructional Strategies (RBIS) faces challenges, particularly in higher education, with Australia having low implementation rates. In the School of Physics at UNSW in Australia, RBIS was introduced in two of three second-year physics courses in 2021: in Quantum Physics and Classical Mechanics and Special Relativity but not in Electromagnetism. Since 2021, these courses have undergone substantial changes, aligning with the new three-term system, addressing challenges posed by the COVID-19 pandemic, and transitioning to a new normal with hybrid teaching. The School of Physics employs a co-teaching format, where courses are taught by two lecturers, each using their preferred teaching methods. This sometimes results in courses being taught with significantly different methods. In this case-study, we explore students' perceptions of the teaching methods in their courses. Data were collected through three surveys with response rates ranging from 18–26% out of 70–90 students per course. The focus group discussions were conducted with 11 second-year students in 2022–2023, supplemented by secondary data from earlier cohorts. Descriptive statistics and thematic analysis were used to analyse the data. Findings revealed diverse opinions on RBIS implementation, the experience of different teaching methods within one course and the shift to other methods within the course.

Session AG: Cross-disciplinary Learning in High School Physics Classrooms I

Location: Harbor Level - Lewis **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Joshua Schneider

(AG-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Mission to Mars Challenge: Where Physics, Robotics, and Computer Science Meet

Presenting Author: Robert Krakehl, Manhasset Secondary School

This talk will discuss the development and implementation of the Mission to Mars Challenge. A low cost robotics challenge that includes programming challenges, engineering designs, and purposeful use of many physics units including kinematics, dynamics, circuits, and more. This challenge demonstrates to students first hand how these three fields need to work in conjunction in order to succesfully complete a task. From middle school to post-secondary, this can work for all age groups. The challenge requires students to program a robot for autonomous motion; use different sensors to navigate an unknown territory; work with external teams to solve on the fly tasks together; and design, build, and test different apparatus to solve unique game based problems as they arise. Unlike other robotics compeitions that exist, this can all fit inside of your classroom and is relatively inexpensive to implement. Additionally it allows for a hands on, engaging, and compeitive method of teaching physics!

(AG-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Spaghetti Bridges in High School Engineering

Presenting Author: Danielle Horton, St. Stephen's Episcopal School

Designing and rapid prototyping spaghetti bridges in a high school engineering class allows students to deeply understand the role of force distribution in truss bridges under static loading. Spaghetti is used due to its behavior under stress and strain as well as ease in multiple iterations. Students investigate greater than 10 types of trusses in order to design their own truss bridge. A truss analysis is then conducted on their design and potential weaknesses are identified. The bridge is tested to failure, using the Vernier Structures and Materials Tester, with the goal of achieving the greatest static load to weight ratio. After testing, a failure analysis is completed and modifications are made to improve the strength to weight ratio. The bridge is re-tested. Students then analyze the results, compare their truss analysis to the location(s) of bridge failure, provide suggestions for a future bridge design, and disseminate their findings through a recorded presentation.

(AG-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Engineering Design in a Physics Classroom

Presenting Author: Philomena Agu, Barbara Jordan High School for Careers

Students were asked to design and create a vehicle capable of accelerating when tested using their knowledge and understanding of motion, force, momentum, and energy transformation concepts. First, the students sketched the vehicles they intended to build, gave them a name, stated the purpose of building the specific vehicle, listed materials they would need, and listed considerations they needed to make, such as completion time, material availability, and vehicle weight. After obtaining approval from the teacher, they built and tested the functionality of their vehicles. The most significant challenges were the inability to plan effectively, absenteeism, failure to make the vehicle move, lack of understanding of the physics behind their vehicle function, and time. At the end of the project, students were asked: What did you learn? Some of their responses included patience, critical thinking, creativity, resilience, teamwork, improvision, hard work, troubleshooting and solving problems. Students felt a sense of accomplishment for designing and creating a car that moves. Students acquired skills they would not usually learn from conducting lab investigations and lectures.

Session AH: PER: Grading and Alternative Grading

Location: Mezzanine Level - Douglass **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Josh Veazey

(AH-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | To Grade, or Not to Grade, That is the Question: Motivation

Presenting Author: Hugh Gallagher, Tufts University

Additional Author | David Hammer, Tufts University

Co-presenting Author | Miguel Vasquez-Vega, Tufts University

Over the 2023-24 academic year, two of us (HG, MV2) have piloted an "ungrading" approach in large lecture introductory physics, similar to Ben Pollard's at WPI (PERC 2022, Poster I-44), in conjunction with changes to curriculum focused on students' learning how to learn. The pilot sits within the larger university context that requires letter grades; like Pollard, our approach has been to support students in grading themselves. One of us (DH) is skeptical, and the three of us are engaged in debate. At a practical level, we are trying to decide whether to recommend the department as a whole adopt this ungrading as a general practice for introductory courses going forward. This talk will describe features of the approach, the motivations for attempting it, and what we hope it would accomplish in students' learning. Finally, we will discuss what evidence from students' work in the course could help us in assessing the merits of ungrading in the context of an introductory course with reformed objectives.

(AH-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | To Grade or Not to Grade, That is the Question: Data and Analysis

Presenting Author: David Hammer, Tufts University

Additional Author | Miguel Vasquez-Vega, Tufts University

Additional Author | Hugh Gallagher, Tufts University

Over the 2023-24 academic year, as discussed in a previous talk, two of us (HG, MV2) have piloted an "ungrading" approach in large lecture introductory physics, in conjunction with changes to curriculum focused on students' learning how to learn. The pilot sits within the larger university context that requires letter grades; like Pollard, our approach has been to support students in grading themselves. One of us (DH) is skeptical, and the three of us are engaged in debate. This talk will focus on the data we have collected and our analyses, in particular with respect our hopes for students' work introductory courses. Those hopes center on students' progress as learners, including their treating physics as "a refinement of everyday thinking" (Einstein, 1936); developing productive attitudes and stamina for engaging with not-knowing; for considering multiple perspectives and for effective and inclusive collaboration. We will present evidence we are examining with respect to these objectives, focusing on (1) equity and inclusion, and (2) engagement with not-knowing.

(AH-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | What do Grades and Grade Components Measure?

Presenting Author: Andrew Heckler, Ohio State University

Grades in physics courses are often comprised of graded components such as midterm and final exams, quizzes, homework assignments, lab assignments, and participation. Here, using data from introductory physics courses at a large public research University, I investigate the extent to which these grade components are related to each other, and how, by their correlations, the grade components group into 2 or 3 factors. While we usually presume that grades are measuring student achievement in physics, we provide insights into what these grouped components may also be measuring by comparing them to other factors such as student procrastination, ACT scores, personality traits, and psychological stress. These results can help us to reflect on how we might more carefully consider graded assignments that fairly assess what we value.

"This research was primarily supported by the Center for Emergent Materials, an NSF MRSEC, under award number DMR-2011876."

(AH-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Investigating the Impact of Post-exam Grade-adjustment Practices in Introductory Physics

Presenting Author: Nicholas Young, University of Georgia

Additional Author | Rebecca L Matz, University of Michigan

Additional Author | Eric F Bell, University of Michigan

Additional Author | Caitlin Hayward, University of Michigan

Exams play an outsized role in typical introductory physics courses, often contributing over half of students' final grades. Various studies have explored how changes to physics exam grading practices could lead to more equitable grade outcomes. This is especially important given the documented gender- and race-based grade inequities in physics and because grades play an important role in determining whether students can get into and stay in the major of their choice, keep their financial aid and scholarships, and ultimately graduate from the university. In this study, we sought to understand how different schemes of exam grade aggregation affected final grades. We examined exam grade data from students enrolled in a first-semester, introductory calculus-based physics course at a large, research-intensive Midwestern university over a 6-year period. We find that most students earn consistent grades across exams or that they earn lower grades on subsequent exams. We discuss the implications of this result for various post-exam grade practices such as dropping the lowest exam grade or giving different weights to each exam based on performance.

(AH-05 9:48 AM-10:00 AM) | Contributed Talk (12 Minutes) | Benefits of Electronic Rubrics and Consistency Checks for Large-Enrollment Physics Exam Grading

Presenting Author: Aidan MacDonagh, Massachusetts Institute of Technology

Additional Author | Alexander Shvonski, Massachusetts Institute of Technology

Additional Author | Byron Drury, Massachusetts Institute of Technology

Additional Author | Shams El-Adawy, Massachusetts Institute of Technology

Additional Author | Mohamed Abdelhafez, Massachusetts Institute of Technology

Additional Author | Michelle Tomasik, Massachusetts Institute of Technology

Grading assessments in large enrollment courses is a logistically challenging process that must balance many factors including equitability, accuracy, and efficiency. Inconsistencies in grading have serious consequences when exam grades are weighted heavily, so a uniform standard must be applied. Working with a large and diverse team of faculty, staff, and teaching assistants, it is especially important to efficiently disseminate, refine, and apply the grading standards across the entire team. We report results from implementing a grading system for handwritten exams that utilizes scanning, electronic rubrics, and a formal consistency check. This system is compared to an earlier traditional approach that involved grading by hand on physical exams. The new system was found to produce more consistency among graders of a given problem than the old system. Analysis revealed fewer statistically significantly inconsistent graders per problem. Logistical benefits of the new system included flexibility to grade remotely, reduction of certain clerical errors, promotion of more consistent rubric design across problems, and easy aggregation of data for a consistency check. Limitations and potential improvements to this system are also discussed.

Session AI: TYC: Professional Development

Location: Grand Ballroom D **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Constance Doty

(AI-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) PER Interest at TYCs - OPTYCs Activities and Future Plans

Presenting Author: Anthony Escuadro, Harold Washington College

In this presentation, we highlight the OPTYCs PER Interest Group's activities of this past year, and share our future goals and plans. This past year, we implemented a sharing session along with the journal clubs, with several sessions devoted to introductory labs, as well as teaching fields, and working with AI in the classroom. OPTYCs is sponsored by AAPT and funded by NSF grant #2212807. More information can be found at: https://optycs.aapt.org.

(AI-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Two-year Colleges' DEI Efforts: Instructor Actions from an OPTYCs Program

Presenting Author: Abigail Daane, South Seattle College

Additional Author | Kristine Lui, AAPT

Additional Author | Dwain Desbien, Estrella Mountain Community College

Additional Author | Sherry Savrda, AAPT

Additional Author | Tran Phung, Whatcom Community College

Additional Author | Jennifer Parsons, Tyler Jr. College

What do you get when you put 11 instructors in a room for a two-day immersive discussion that centers students in DEI-effective practices? A lot of amazing actions to share! In this presentation, we will first give an overview of the DEI Capacity-Building Program organized by OPTYCs, The Organization for Physics at Two-Year Colleges. Participants in the first cohort of this two-year program have already begun work towards shifting practices to increase DEI in their classrooms. We share some highlights of their work that came out of the two-day retreat in January 2024 and how that work has continued together during virtual follow-up meetings. A second cohort will begin next year. Applications for this program will open summer 2024, and all interested two-year college faculty who teach physics-related courses are invited to apply. OPTYCs, including this program, is supported by the National Science Foundation under Grant No. 2212807.

(AI-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | OPTYCs Continuing Professional Development Workshops and Tandem Meetings: An Update

Presenting Author: Paul Heafner, Independent Scholar

Co-presenting Author | Tom O'Kuma, Lee College

Co-presenting Author | Kris Lui, AAPT/OPTYCs

In this talk, I will discuss workshops in year two of the OPTYCs grant, both those that have occurred and those planned as of conference time. We are striving to address a broader range of topics, including alternate curricula that require effort to implement. I will discuss potential barriers to adopting some of these curricula and issues related to workshop attendance. While interest and feedback continue to be, respectively, high and positive, we must address some issues we have documented. OPTYCs is funded by NSF-DUE-2212807.

(AI-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Beyond Retention: The Design of a New Peer Mentor Program for Transfer Students

Presenting Author: Frank Dachille, Department of Physics and Astronomy, Michigan State University

Additional Author | David Tran, Michigan State University

Additional Author | Ashley Hewlett, Transfer Student Success Center, Michigan State University

Additional Author | Charles Jackson, Transfer Student Success Center, Michigan State University

Additional Author | Rachel Henderson, Department of Physics and Astronomy & CREATE for STEM Institute, Michigan State University

Additional Author | Vashti Sawtelle, Lyman Briggs College & Department of Physics and Astronomy, Michigan State University

We present the design and implementation of the Transfer Experience Mentoring Program (TEMPO) at Michigan State University (MSU), which launched in the Fall of 2023. TEMPO is designed to support transfer students through the transition between community colleges and MSU. At the national scale, students who first enroll at community colleges are historically undersupported, especially through the transition into the bachelor's granting institution. TEMPO utilizes resources from MSU to support a student's transition from their final semester of community college and into their first semester at MSU. TEMPO is supported by campus partners at MSU , and financially from the Howard Hughes Medical Institute Inclusive Excellence 3 project. In this presentation we will share how TEMPO represents a method of bridging the transfer transition gap between community college and a bachelor's granting university using peer mentoring, mentor training and resources sharing, and community building activities.

Session AJ: PhysTEC: Teacher Communities

Location: Grand Ballroom C **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Adam LaMee

AJ-01 10:00 AM-10:48 AM) | | QuarkNet: Supporting Physics Teachers Communities for 25+ Years

Presenting Author: Shane Wood, QuarkNet

QuarkNet is a National Science Foundation sponsored, long-term teacher professional development program that immerses teachers in cutting-edge physics research and supports them in developing instructional strategies that bring authentic scientific and engineering practices into their classrooms. QuarkNet began in 1998, and continues to support collaborations between physics teachers and mentor physicists at over 50 centers at universities and national labs across the country today. In this session, you will learn about some of the factors that continue to keep these partnerships strong over time. In addition, you will get a chance to try out some of the activities and resources that QuarkNet provides.

QuarkNet is funded by a grant from the National Science Foundation.

Session AK: PER: Understanding Physics Graduate Program Experiences

Location: Concourse Level - Commonwealth B **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Douglas Petkie

(AK-01 9:00 AM-9:12 PM) | Contributed Talk (12 Minutes) | Making Graduate Programs more Inclusive: An AGEP Pilot in Physics

Presenting Author: Charles Henderson, Charles Henderson

Additional Author | Geraldine Cochran, the Ohio State University

Additional Author | Diane Codding, Northwestern University

Additional Author | Bennett Goldberg, Northwestern University

Additional Author | Diana Sachmpazidi, University of Maryland

Additional Author | Evangeline Su, Northwestern University

Physics is among the least diverse disciplines in higher education. Past efforts at improving diversity centered on fixing students by focusing on gaps in academic preparation or psychosocial elements, such as motivation and self-efficacy. While such efforts are important, they do not address the underlying structural barriers to inclusion. In this talk, we introduce a new project that seeks to shift the focus from the students to program practices/policies and mindsets/values of institutional actors that create barriers to equity and inclusion. A cohort of 15 R1 physics programs has committed to engaging in deep and systemic change through this project to transform their programs into creating and sustaining a welcoming and supportive environment for historically excluded groups. In this presentation, we will describe the goals and structure of the project as well as our plans to document the impacts on these 15 physics graduate programs.

This presentation is based upon work supported by the National Science Foundation under Grant No. 2330015.

(AK-02 9:12 PM-9:24 PM) | Contributed Talk (12 Minutes) | Exploring Retention Rates in Physics Graduate Programs

Presenting Author: Christopher Overton, UGA

Additional Author | Nicholas B Young, UGA

Graduate students and graduate degree holders play a central role in the growth of science and technology for both institutions and the country. They serve as researchers pursuing advances in science and educators preparing the next generation of scientists. Historically STEM graduate programs have had a low retention rate, potentially causing a high cost for both those leaving the programs and for society at large. In this talk we look at the past two decades of the American Institue of Physics' annual rosters with a focus on the number of graduate students in programs and the graduation rates for these students. By observing the trends over the past two decades, we can make general observation about the current state of graduate education in the United States. We find that while over the past 20 years the general trend has been towards an increase in graduate students in programs across the country as well as annual degrees earned. We find that there is variation in the retention rates of different programs. Our results can better inform prospective graduate students and faculty about current trends in the field of education and potentially inspire change.

(AK-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Investigating the Requirements of a Physics Ph.D.

Presenting Author: Bill Bridges, Kansas State University

Additional Author | Daniel Sharkey, University of Central Florida

Additional Author | William Heredia, University of Central Florida

Additional Author | Rachel Henderson, Michigan State University

Additional Author | Jacquelyn J Chini, University of Central Florida

Additional Author | James T Laverty, Kansas State University

As physics graduate programs adapt to an ever-changing world, it is important to consider an update to their practices of assessing students. This aspect of graduate education is currently not well documented. A lack of how each physics graduate program assesses their students potentially hamper those programs looking to stay updated with their practices. We are investigating the requirements and expectations that graduate programs have for their graduate students. We conducted a landscape study documenting the ways in which students are assessed during their Ph.D. This includes practices such as written examinations, courses required, and timeline to graduation. These results were compared to determine alignment of the varying practices among universities. With these results we can provide a resource for those programs looking to update their practices and a foundation for further investigations into physics graduate education programs.

(AK-04 9:36 PM-9:48 PM) | Contributed Talk (12 Minutes) | Exploring a First-Year Physics Graduate Student's Self-Efficacy Using Mixed Methods

Presenting Author: Vicky Phun, Michigan State University

Additional Author | Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Self-efficacy–or the confidence in one's ability to perform a task–has been shown to be an important predictor of students' STEM academic performance and persistence at the undergraduate level. However, there is limited research on the development of students' self-efficacy during their graduate education experience, particularly among physics graduate students. Considering the wide variety of their responsibilities (e.g., coursework, research, and teaching), there may be unique supports and challenges that influence students' self-efficacy. This pilot study explores self-efficacy domains among a first-year physics graduate student through her participation in an explanatory mixed-methods research design. The design includes the Experience Sampling Method (ESM) coupled with individualized daily journal prompts. In this talk, we will present the results and implications within a physics graduate school context including the importance of capturing non-academic experiences that may influence one's self-efficacy in graduate school.

(AK-05 9:48 PM-10:00 PM) | Contributed Talk (12 Minutes) | How Variation in Research Interest Development Affects PhD Students' Search for a Research Group

Presenting Author: Mike Verostek, University of Rochester and Rochester Institute of Technology

Additional Author | Casey W. Miller, Rochester Institute of Technology

Additional Author | Benjamin M. Zwickl, Rochester Institute of Technology

Physics PhD students consider finding a research group to be an important goal in their first year of graduate study, and research indicates that helping students successfully navigate the group search process may positively impact retention. It is therefore crucial to investigate how students go about finding a group in order to properly support students in their search. Here, we explore how physics PhD students find a group that is congruent with their own research interests. Using semi-structured interviews with 40 first and second year physics PhD students, we show that some students entered their programs intending to work with a specific research group, while many others were unsure of what research they wanted to pursue. This impacted when they found a group, as students with broad interests tended to take longer to join and were more likely to switch advisors. However, students with narrower interests expressed concerns with committing to their research group, fearing that they may have missed out on a better opportunity elsewhere. Our results emphasize the inhomogeneity in physics PhD students' interests and experiences upon entering graduate school, and the importance of providing departmental support for students of all backgrounds during their group search.

Session AL: Interactive Session: Advanced Topics for HS

Location: Grand Ballroom E **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Frank Lock

(AL-01 9:00 AM-9:24 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | The Importance of Radio Astronomy

Presenting Author: Valarie Bogan, National Radio Astronomy Observatory (NRAO)

Do you teach Physics or Astronomy to middle or high school students? If so then this session is for you! Come and learn about a classroom-ready lesson on radio astronomy. The lesson begins by helping students develop an understanding of radio waves. Once they have mastered the physics concepts they will apply that knowledge to a practical exercise demonstrating the functioning of radio telescopes. Upon grasping the data collection process, students will explore a specific telescope and gain insight into the crucial research conducted at that site. During this session, you will get to experience the activity which models how radio telescopes work, and will gain access to the lesson plan and all student pages. At the end of the session, one lucky participant will walk away with all the necessary materials for teaching this lesson.

Session AM: Make, Do, Play, Learn: Revolutionary Ideas to Teach Physics

Location: Concourse Level - Commonwealth A **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Nina Morley Daye

Interactive Session. There will be multiple presenters with materials and instructions for participants to use to create an item to use to teach physics concepts. Participants will move around the room and visit various stations. This session has been sponsored by the Pre-High School Committee and hosted by PTRAs (Physics Teaching Resource Agents) for over 10 years. These can be used to teach physics concepts at a variety of levels. Each item will have the instructions available and be linked to the NGSS.

Session AN: PER: Innovative Assessment Methods

Location: Stone **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Trevor Smith

(AN-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Assessment of Expert-like Attitudes and Scientific Reasoning Skills with Multiple Instruments

Presenting Author: Raymond Zich, Illinois State University

In a multi-semester study of the effects of two instructional interventions in a general physics course, the expert-like attitudes and scientific reasoning skills of students were measured by the Colorado Learning Attitudes about Science Survey (CLASS), Lawson's Classroom Test of Science Reasoning (CTSR), and Montana State University's Formal Reasoning Test (FORT). In the first intervention students watched videos on physics topics and completed worksheets testing comprehension of concepts and the scientific reasoning shown. In the second intervention students manipulated PhET simulations and completed worksheets. Two control and six treatment semesters were studied. Expert-like attitudes were assessed by the CLASS and scientific reasoning skills were assessed by the CTSR and the FORT. An earlier study showed low correlation between the pretest and posttest CLASS results and posttest CTSR scores for both the overall scores and the scores from the question groups measuring specific attitudes or reasoning skills. The study was expanded to include assessment with the FORT, and a comparison of the CLASS, CTSR, and FORT scores are presented along with a discussion of implications for instruction given this apparent decoupling of expert-like attitudes and reasoning skills.

(AN-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Bayesian Networks for the Analysis of Student Progression in an Introductory Course

Presenting Author: John Pace, West Virginia University

Additional Author | John C Stewart, West Virginia University

Bayesian networks trained on student college GPA and weekly grade data were used to analyze students in an introductory electromagnetism course. The conditional dependency structures of various models were examined as well as their conditional probability distributions, with the properties of students who ultimately earned passing and failing grades analyzed. Classification models using queried probabilities with the decision threshold tuned to the fail rate of the course were tested on student data from a semester not included in the training data. The predictive performance of the model was analyzed over time through the semester, with comparisons to prior work using logistic regression classifiers and simple grade-based prediction. Advantages of Bayesian networks are discussed, including ease of interpretation and conditional probability querying.

(AN-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Extending Curricular Analytics to Analyze Undergraduate Physics Programs

Presenting Author: Amanda Nemeth, West Virginia University

Additional Author | John Hansen, West Virginia University

Additional Author | John Stewart, West Virginia University

Curricular Analytics (CA) is a quantitative method that analyzes the sequence of courses (curriculum) that students in an undergraduate academic program must complete to fulfill the requirements of the program. When applied to a curriculum, CA returns a complexity score that indicates the overall complexity of the program. This study compares the complexity of undergraduate physics programs at 60 institutions in the United States. The institutions were divided into three tiers based on national rankings of the physics graduate program, and the means of each tier were compared. No significant difference between the means of each tier was found, indicating that there is not a relationship between program complexity and program ranking. Further analysis focusing on the core physics and mathematics courses for each tier identified significant differences in the number of required core courses and the core complexity per course. Programs with the highest rankings required fewer core courses while having a higher core complexity per course.

AN-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Relationship Between Course Grades in Introductory Physics and Pre-instruction Assessment Scores

Presenting Author: David Meltzer, Arizona State University

Additional Author | Dakota H. King, University of Arizona College of Veterinary Medicine

We have examined the relationship between various pre-instruction assessment measures and final course grades for students enrolled in introductory general physics courses at five campuses of four universities; the total sample included 26 separate classes and over 2000 students. The three assessments were the Force Concept Inventory, the Lawson Test of Scientific Reasoning, and a mathematics diagnostic test that we have developed and tested over the past seven years. We find, with nearly 90 percent consistency, that top-quartile scorers on the pre-instruction assessments have double or greater probability of receiving high (top quartile) course grades, and half or less probability of receiving low (bottom quartile) course grades, compared to students who scored in the bottom quartile on the assessments. Predictor variables have some inter-correlation but models incorporating two or more predictors generally have more predictive power than single-variable models. The most successful sets of predictors appear to vary from course to course. Linear models do not fully reflect the strong relationship between predictor variables and grade outcomes for the top and bottom quartiles, and so we are exploring models that restrict the sample to the top and bottom quartiles only.
Supported in part by NSF DUE #1504986 and #1914712

(AN-05 9:48 AM-10:00 AM) | Contributed Talk (12 Minutes) | Conceptual Growth Curves: Communicating Gains Across Populations

Presenting Author: Paul Miller, West Virginia University

Additional Author | Elaine Christman, West Virginia University

Additional Author | John Stewart, West Virginia University

In the well-known Hake1 paper, he used normalized gain to facilitate comparison of outcomes on conceptual evaluations across student populations "over diverse student populations with widely varying initial knowledge states." However, there is substantial evidence that it does not correct for differences in prior preparation. Based on our multiyear dataset, we find that prior preparation is well-modeled by pretest score. We propose a new representation of student-level data, the Conceptual Growth Curve (CGC). The CGC graphically displays the efficacy of instruction based on preparation, using the natural variation of a student population. We argue that this allows more meaningful comparisons—between populations and with published research—possible.
1. Am. J. Phys. 66, 64-74 (1998).

Session AO: Incorporating Climate Change and Earth Science in Physics Classrooms

Location: Lobby Level - Otis **Time:** 9–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Danielle Bugge

(AO-01 9:00 AM-9:12 AM) I Contributed Talk (12 Minutes) I Climate Change Teaches Energy

Presenting Author: Thomas Gibbons, Clinton Community College, Retired

Introductory energy topics include conservation thereof, power, intensity, temperature change related to heat absorption, and change of phase. Climate change offers good examples of these. Heat absorbed by Earth's melting ice and heat absorbed vs. temperature change in the land, ocean, and atmosphere are calculated by the familiar methods. There has been much recent research yielding data that can be obtained and used by elementary physics students, who could perform similar though simplified calculations. When all the heat is added, it can be accounted for by the Earth's energy Imbalance, which is the difference between incoming solar energy and energy radiated by the Earth. This difference drives global warming. This circumstance should help teach energy conservation, power, intensity, and climate change itself. This presentation will give simple examples and references with more detailed examples left for a poster session.

(AO-02 9:12 AM-9:24 AM) I Contributed Talk (12 Minutes) I Climate Change Taught through the Lens of Systems and Feedback

Presenting Author: Frances Johnson, Phillips Exeter Academy

Co-presenting Author | Scott Saltman, Phillips Exeter Academy

Co-presenting Author | David Gulick, Phillips Exeter Academy

In our algebra-based first year high school physics course, we teach a two week climate change and feedback unit, that acts as a capstone unit for the year. In the first week, we review traits of systems, such as open vs closed, using examples from across the physics year. Through lab activities and homework, students learn to identify positive and negative feedback and to make flowchart diagrams. In the second week our attention turns to climate systems. We teach the physics of climate change, including greenhouse effect, radiative forcing and Earth's energy budget. Students learn to interpret data and do Fermi-type calculations on earth's energy and temperature. We explore climate feedback loops (e.g. algae growth and artic melting), discussing how negative and positive feedback act to mitigate or magnify the climate effect.

(AO-03 9:24 AM-9:36 AM) I Contributed Talk (12 Minutes) I Coding for a Cooler Planet: Improving Students' Understanding of the Greenhouse Effect Through Computational Modeling

Presenting Author: Luke Conlin, Salem State University

Co-presenting Author | Justin Zimmerman, Benjamin Banneker Academic High School, Washington, DC

Additional Author | Bridget Knight, Salem State University

Additional Author | Aaron Dwyer, Salem State University

Additional Author | Emi Pilla, Salem State University

In high school physics classrooms, students often learn most effectively by engaging in the disciplinary practices of professional physicists. Computational modeling is an essential practice among physicists in today's world, but incorporating it into physics classrooms brings many challenges. Students have unequal access to technology and different levels of experience with coding. Moreover, adding complexity to already intricate concepts could backfire. How can we use modeling to enhance, not impede, students' understanding of physical phenomena? We report on a pilot study from a research-practitioner partnership in which we collaboratively designed and implemented a computational modeling unit on the physics of the greenhouse effect. Students used and modified computational models to explore factors influencing Earth's temperature equilibrium. Pre-posttest gains and video analysis of classroom interactions reveal significant improvements in students' understanding of the greenhouse effect and in their computational skills. We discuss the instructional elements that likely fueled these gains.

Session BA: Much More Than ChatGPT – AI-tools for Learning and Teaching II

Location: Harbor Level, Harbor I **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Jochen Kuhn

(BA-01 10:00 AM-10:24 AM) | | Generative AI-based Tailored Feedback System for Diverse Self-Regulated Learning

Presenting Author: Chiara Hortmann, Ludwig-Maximilians-Universität München

Additional Author | Niklas Stausberg, Ludwig-Maximilians-Universität München

Additional Author | Steffen Steinert, Ludwig-Maximilians-Universität München

Additional Author | Karina Avila, Ludwig-Maximilians-Universität München

Additional Author | Jochen Kuhn, Ludwig-Maximilians-Universität München

Additional Author | Stefan Küchemann, Ludwig-Maximilians-Universität München

In a time marked by growing student diversity, supporting self-regulated learning poses a significant challenge for educators. Generative AI-models, such as Large Language Models (LLM) and others, can support teachers in several ways. This presentation introduces a possible example for an Adaptive Feedback System that leverages Large-Language-Models such as ChatGPT (LEAP). Recognizing the valuable role of feedback in nurturing self-regulated learning, LEAP delivers tailored guidance to students. The presentation delves into the platform's features and application, highlighting its versatility across a range of learning processes. Serving as a dynamic tool, LEAP offers personalized support to students as they navigate diverse learning tasks, accompanying them throughout their educational journey.

(BA-02 10:24 AM-10:48 AM) | | Tell me a Science Story: Using Generative AI for Storytelling in physics classes

Presenting Author: André Bresges, University of Cologne

Additional Author | Benjamin Niehs, Europaschule Bornheim

Storytelling is seen as influential in stimulating student interest, aiding the flow of lectures, making material memorable, overcoming resistance and anxiety, and building rapport between teachers and students (Green & Clark, 2019). Cognitive psychologists even see storytelling as a primary mode of knowledge transfer throughout human history (Schank & Abelson, 2013). But what if you do not feel confident in developing stories, let alone telling them to your physics class? Let an AI do the job! In our research study, we developed prompts for ChatGPT to develop stories focusing on scientific issues within the UN's Global Sustainability Goals. For example, generating wind energy with offshore wind turbines sounds like a good idea until Anna, an 8-year-old girl, finds a young seal on the beach and discovers that the drilling noise has disoriented it, causing it to get lost and separated from its parents. We describe a process for developing stories like this collaboratively with students in classes using a Discord server, and illustrating them with AI-generated images using Midjourney. The influence of stories on students and whether human-generated stories can be distinguished from AI-generated stories was tested in a study at four different schools with 309 students from grades 7 to 10.

Green M, Clark J L (2019): Narrative warmth and quantitative competence: Message type affects impressions of a speaker. PLoS One, https://doi.org/10.1371/journal.pone.0226713

Schank R C, Abelson R P (2013): Scripts, plans, goals and understanding: An inquiry into human knowledge structures. Psychology Press

Session BB: Labs and Apparatus: Introductory Labs II

Location: Harbor Level, Harbor II **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Virginia Card

(BB-01 10:00 AM-10:12 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Some Innovations in the Construction of a Light Source for Optics Experiments

Presenting Author: IVAN CULABA, Ateneo de Manila University

In the Philippine context, especially in most of the public high schools, there are no dedicated laboratories for students to perform Physics experiments. The available laboratories are common facilities for Biology, Chemistry, Earth Science and Physics activities. As expected, these rooms cannot be darkened for optics experiments. Based on these conditions we developed a novel light source wherein the image formed on the screen is clearly visible even in a well-lighted room. In addition, the object used in the light source can be changed, e.g. the usual cross arrows and the old positive slides of the moon. This light source has already been donated and used by some local schools.

(BB-02 10:12 AM-10:24 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | A Two-Session, Qualitative and Quantitative Lab Experiment on Faraday's Law for Introductory Physics Students

Presenting Author: Scott Gianelli, Suffolk County Community College

Faraday's Law of Induction is an important but challenging topic for introductory physics students. A two-session experiment has been designed for students taking introductory calculus-based physics. The first session is non-mathematical, combining traditional variants of Faraday's experiment with an additional part designed to test Lenz's Law. This part demonstrates the different ways that the magnetic flux through a hand-wound coil of wire can vary in the presence of a solenoid with a large current, while relating the direction of the current induced in the wire to that in the solenoid. The second part tests the equation for Faraday's Law. Students wrap loops of wire around a solenoid with a triangle-wave current. An oscilloscope is used to show visually that the induced voltage in the wire is proportional to the negative of the derivative of the changing magnetic flux. Students vary the frequency of oscillation (f) and the number of loops of wire wrapped around the solenoid (N), and plot the induced voltage vs. these quantities. Agreement between the obtained slope and the theoretical value to within 2% is possible for the plot of induced EMF vs. f. More care is required when N is varied, but agreement within 10% is still possible.

(BB-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Addressing Teaching Assistant Shortages While Enhancing Teaching Quality

Presenting Author: Umesh Silwal, University of North Carolina at Charlotte

Additional Author | Richard Allen Dudley, University of North Carolina at Charlotte

Teaching assistants (TAs) play a crucial role in promoting effective teaching and enhancing student learning, especially in settings like large classes, active learning environments, and lab courses. However, many academic institutions frequently experience shortages of TAs, leading them to rely on hiring non-physics graduate students or increasing the teaching workload of instructors. To tackle this issue, we have initiated a program to recruit undergraduate TAs and equip them with 1-credit fundamentals of teaching courses as part of their training at the University of North Carolina at Charlotte. In this presentation, I will provide an overview of the program and its various benefits.

(BB-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | A Modern Suppoirt Que System in the Physics/Electronics Lab

Presenting Author: Lars Hellberg, Chalmers University of Technology

Additional Author | Lars Bengtsson, University of Gothenburg

Additional Author | Josef Anderssson, University of Gothenburg

This contribution describes a queuing system for TA support to the students in our electronics laboratory. The laboratory accomondates 40 students at 20 identical lab stations. To ensure that the students get support in the order they request it, they have until now, had to go to a white board and sign up on a list and note if they need technical assistance or want to report a completed task (we prioritize assistance over reporting). This has resulted in unnecessary movements in the laboratory with all the disadvantages this entails. In addition, it has been perceived as an outdated solution. In the new queuing system, each lab station has been equipped with a three-way switch with the modes: Help, Done and Report - in that order. Students select the type of suppoprt they need with the switch and the TA resets it to Done when they arrive at the lab station. Technically, the switches are mounted in small boxes with simple microcontrollers which in turn are connected in a CAN network. Everything is controlled from a PC that collects all requests for assistance and presents the queue on monitors in the ceiling of the laboratory in a similar way to some take away restaurants.

Session BC: Incorporating the High School Photo Contest into Your Classroom (Invited Panelists)

Location: Harbor Level, Harbor III **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Danielle Bugge

(BC-01 10:00 AM-10:24 AM) | | Delighting in the Beauty of the Physical World

Presenting Author: J. Schober, Trinity School, NYC

While physics is a technical subject, it is also beautiful. Consequently, I developed an overarching, unmeasured objective in my physics course: "I will seek and take delight in the beauty of the physical world." I ask students to reflect on this objective and to consider how their ability to "see" physics grows during the year. One of the central activities I invite students to participate in is AAPT's High School Physics Photo Contest. I'll share how I scaffold participation in the Photo Contest through the classroom environment; a weekly "Astrophoto Friday" email blast; a course-long focus on multiple representations in physics; opportunities for photo and travel; and even how I structure homework and assessments to cultivate an aesthetic appreciation of physics -- strategies that can enhance the aesthetic appreciation of physics in your own classroom.

(BC-02 10:24 AM-10:48 AM) | | Highlighting the "A" in STEAM: The Physics in Focus Project

Presenting Author: Leila Madani, Sleepy Hollow High School

Co-presenting Author | Kerrie Sansky, W.L. Morse Elementary School

The Physics in Focus Project was developed as a collaborative initiative to engage students in and beyond the classroom. At the outset, it was designed to achieve five goals: 1.) for students to examine everyday life through the lens of physics, 2.) encourage the artistic expression of physics 3.) provide an alternative form of student assessment 4.) present the projects to elementary school students, and 5.) showcase student STEAM work within the Sleepy Hollow/Tarrytown communities. Out of the students who chose to complete this project, the top 15 submissions were selected for the AAPT annual photo contest. This session will highlight the project requirements, rubric, timeline, checkpoints, elementary school collaboration model, and community outreach strategy. Samples of student work and feedback will be presented, with accompanying tips and suggestions for strong photo contest submissions.

Session BD: 21st Century Astronomy and Physics in the Classroom II

Location: Lobby Level - Marina Ballroom II **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Peggy Norris

(BD-01 10:00 AM-10:12 AM) | QUARKNET: Contemporary Particle Physics for High School Teachers and Students

Presenting Author: Richard Dower, Roxbury Latin School/QuarkNet

For 25 years, high school teachers and students in New England have benefitted from the national QuarkNet program headquartered at Fermi National Accelerator Laboratory (Fermilab) in Illinois. Beginning with teacher research experiences supervised by physics professors at Northeastern University and Boston University in 1999 and followed by teacher workshops at Roxbury Latin School and student Masterclasses at Northeastern, teachers and students became acquainted with current research in particle physics and astrophysics. Tours of research facilities, e. g. MIT's Plasma Science and Fusion Center, and Red Sox game attendance enlivened our meetings. In addition to school-year meetings and summer workshops in Boston, our QuarkNet teachers attended particle physics Data Camps at Fermilab and International High School Teachers programs and International Teacher Weeks programs sponsored by European Center for Nuclear Research (CERN) in Switzerland. Our teachers and students built and experimented with cosmic ray detectors in their classrooms. Students explored contemporary particle physics data in Masterclasses and submitted proposals for experiments at CERN. Students see physics concepts like momentum and energy conservation applied in a modern research context. The QuarkNet program makes current ideas, research methods, and results in particle physics approachable.

(BD-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Electric Vehicles: Motivation for E&M Topics

Presenting Author: Richard Gelderman, Western Kentucky University

Compared to the topics from introductory mechanics, electricity and magnetism can be a much more interesting and relevant aspect of physics. However, many students become stultified by the combination of increased reliance on calculus and with their lack of familiarity with subatomic particles, potential, and fields. Happily, our current learners are the generation that will encounter electric vehicles as a commonplace feature of their lives, and the details of electric vehicles provide wonderful motivation for most sections of an E&M course. Basic circuits, charging stations, capacitors for energy storage, and regenerative braking are examples presented to demonstrate how 21st century physics can be incorporated into physics courses.

(BD-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Performing Bell Tests with IBM Quantum Computers

Presenting Author: Jarrett Lancaster, Maine Maritime Academy

I will discuss how freely-accessible, cloud-based IBM quantum computers can be used to perform tests of Bell's inequality and its generalizations. The simplest application enables students to perform a version of the same experiment that won the Nobel Prize in physics last year with no specialized equipment. These activities were successfully incorporated into a junior/senior-level undergraduate course on quantum mechanics. Additionally, I will outline how this procedure can be scaled up to perform some recently proposed experiments that demonstrate the necessity of complex numbers in the traditional formulation of quantum mechanics and the existence of multipartite entanglement.

(BD-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Ofrenda of a Fallen Star: The Art of Strong Gravity

Presenting Author: Matthew Quiroz, Ysleta High School

Recently, there have been numerous advances in the field of strong gravitational physics. Theorists have revealed striking relationships between gravity and quantum information, while experimentalists have detected gravitational waves and observed the shadow of our galaxy's supermassive black hole. The complexity of these ideas presents a challenge in how to introduce them to young students. I address this through an interdisciplinary project where introductory astronomy students are tasked with presenting the story of a star's life, death, and eventual fate in the form of a traditional Día de los Muertos altar. Along the way, they will encounter various quantum mechanical and relativistic phenomena as they explore the dynamics of stellar evolution and the techniques researchers use to perceive the warped side of the universe.

Session BE: Learning from the Eclipse I

Location: Lobby Level - Marina Ballroom III **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Ann Schmiedekamp

(BE-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | St. Catherine University Collaborative Undergraduate and Alumna Research and Outreach Experiences During the 2024 Total Solar Eclipse

Presenting Author: Erick Agrimson, St. Catherine University

Additional Author | Abby Conrad, St. Catherine University

Additional Author | Bronwyn Hicks, St. Catherine University

Additional Author | Kadiatu Kaya, St. Catherine University

Additional Author | Odunola Adewale, St. Catherine University

St. Catherine University traveled to the April 8th 2024 total solar eclipse in the path of totality at our host institution Taylor University. We present a brief overview of three different projects that our all-women's undergraduate team and alumna participated in during this celestial event.

1. Conducting atmospheric science research looking at atmospheric changes using radiosondes as part of the National Eclipse Ballooning Project (NEBP).
2. Presenting outreach experiences in conjunction with our hosts Taylor University.
3. Summarizing Regener-Pfotzer (R-P) maximum studies looking at charged and neutral particles before and during the eclipse making use of Geiger Müller (GM) detectors as well as personal neutron dosimeters (PNDs).

(BE-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Insights from a Total Solar Eclipse Research Expedition: Educating Students and Engaging the Public

Presenting Author: Benjamin Boe, Wentworth Institute of Technology

Additional Author | Martina Arndt, Bridgewater State University

Additional Author | Nicole Glen, Bridgewater State University

Additional Author | Shadia Habbal, University of Hawaii

In this talk, we will discuss the outcomes of both student involvement and public outreach during our 2024 total solar eclipse research expedition. Our research group, known as The Solar Wind Sherpas, is dedicated to observing total solar eclipses worldwide, conducting essential photometric and spectroscopic analyses of the solar corona. This year's expedition offers a unique moment to engage several undergraduate and graduate students, providing them with transformative hands-on research experience. Moreover, we'll showcase our direct outreach efforts, including presentations at the Kerrville, Texas eclipse festival, which will be attended by thousands of eager eclipse observers. Through this talk, we'll illuminate the outcomes of our collaborative efforts, emphasizing the educational and scientific significance of total solar eclipses.

(BE-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Cosmic Ray Shower Studies by High School Students – Design Through Execution

Presenting Author: Nathan Unterman, New Trier High School

High school students designed a cosmic ray shower experiment for the recent total solar eclipse. This will discuss the process of arranging the experiment and the protocol students created for the experiment. Some preliminary results will be available.
QuarkNet NSF 1219444

(BE-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Integrating High School and College Students and Teachers in an Eclipse Ballooning Team

Presenting Author: Peggy Norris, Black Hills State University (retired)

The South Dakota / Wyoming Eclipse Ballooning Team is a collaboration between South Dakota School of Mines and Technology (SDSMT), four area high schools, and one middle school. The team traveled to Farmington, NM in October 2023 and the Dallas metro area in April 2024. During each eclipse high altitude weather balloons were launched to collect atmospheric data, photos and livestreamed video of the eclipse. In addition, payloads designed and built by the high school students were flown. The K-12 students and teachers were integrated into the project through two four-day summer workshops in 2023. A number of undergraduates joined the project in September and participated in practice launches and the two eclipse trips. We will discuss the challenges and benefits of integrating the college and high school groups into one team learning experience.

Session BF: PER: Beyond Intro II

Location: Lobby Level - Marina Ballroom IV **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Cristian Bahrim

(BF-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Providing Actionable Feedback to Instructors with a New Modular Thermodynamics Assessment

Presenting Author: Michael Freeman, Department of Physics, University of Colorado, 390 UCB, Boulder, CO 80309

Additional Author | Bethany R Wilcox, Department of Physics, University of Colorado, 390 UCB, Boulder, CO 80309

Additional Author | James T Laverty, Department of Physics, Kansas State University, Manhattan, KS 66502

Additional Author | Tyler Garica, Department of Physics, Kansas State University, Manhattan, KS 66502

Additional Author | Bill Bridges, Department of Physics, Kansas State University, Manhattan, KS 66502

Additional Author | Parker Poulos, Department of Physics, Kansas State University, Manhattan, KS 66502

To improve student learning, measuring it with tools that facilitate informed course modifications is important. Historically, standardized assessments were these measurement tools. To be effective at informing change, assessments need to provide actionable and clear feedback to instructors. Traditionally, this feedback has been average scores/distributions, which are known to be difficult for instructors to interpret. A second issue is that the topics assessed are static, i.e. instructors cannot customize what topics the instrument targets. However, in some courses, including upper-division thermal physics, there is significant variation in what content is taught, motivating the need for modular assessment. Here, we present the goals and features of a newly developed assessment - The Thermodynamics and Statistical Physics Assessment, which is a modular assessment that provides instructors with actionable feedback - and describe how it represents a new model for these assessments to serve as tools to help instructors improve future courses.

(BF-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Investigating Self-Regulated Learning as a Framework for Research-based Assessment Feedback

Presenting Author: Parker Poulos, Kansas State University

Additional Author | Michael Freeman, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Additional Author | James T Laverty, Kansas State University

A primary focus of the Physics education research community is to support instructors in improving the courses they teach. Physics education researchers do this through various avenues, including developing research-based assessments aimed at evaluating student understanding of course content. However, instructors may find difficulty in identifying ways to improve their courses from assessment scores alone. One way to approach writing useful feedback for research-based assessments is to use elements of self-regulated learning (SRL) theory to guide the structure of the feedback. This study investigates the viability of using SRL to structure research-based assessment feedback. To do this, we have conducted a thematic analysis on 14 interviews with instructors of thermal and statistical physics. These interviews focused on how useful the faculty found feedback given by the Thermal and Statistical Physics Assessment (TaSPA). The feedback from TaSPA was chosen because it was designed using guidelines derived from SRL theory. We found that SRL helps to structure feedback, but more is needed to guide the development than SRL alone. We discuss possible future studies to investigate ways to improve research-based assessment feedback designed with SRL in mind.

(BF-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Student Sense-making in Upper-level E&M in the Context of Problem-solving Involving Method of Images

Presenting Author: Jaya Shivangani Kashyap, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Instructors and researchers who focus on student sense-making try to understand 'how' students navigate the problem-solving process. Understanding these mechanisms plays an important role in helping students become good problem solvers. In particular, investigating student sense-making in the context of physics problem-solving can be useful for developing curricula and pedagogies to help students learn. We used individual interviews to investigate student sense-making in upper-level E&M in the context of problem-solving involving method of images as part of the development and validation of a research-based tutorial. Some of the interesting instances and findings will be presented.

Jaya Shivangani Kashyap's presentation sponsored by Chandralekha Singh (Jaya Kashyap is a new Ph.D. student who will become an AAPT member before the AAPT meeting)

(BF-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Tutorials for General Relativity

Presenting Author: David Syphers, Eastern Washington University

Active learning methods like in-class tutorials have proved to be a helpful approach for better instruction of physics topics, but some areas of physics remain without much developed material. General relativity is a key one of these neglected areas, in part because the topic seems so esoteric and even many physicists don't ever engage with it. However, students are fascinated by black holes, quasars, the Big Bang, gravitational waves, and so on, and these are topics that can be covered mathematically in upper-division undergraduate courses on astrophysics or relativity. I have begun development of tutorials aimed at solidifying undergraduate understanding of the metric in general relativity. The metric is perhaps the most important part of relativity and the one with the most immediate payoff, and I'll discuss how we can help students become comfortable with it.

Session BG: Effective Practices for Developing Scientific Reasoning and Decision-Making Abilities I

Location: Harbor Level, Lewis **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Joshua Schneider

(BG-01 10:00 AM-10:24 AM) I I Promoting Causal Reasoning in the Introductory Physics Lab Course

Presenting Author: Kathleen Koenig, University of Cincinnati

Additional Author | Lei Bao, The Ohio State University

Additional Author | Krista E. Wood, University of Cincinnati

Causal reasoning is an important skill in decision-making, particularly when it is necessary to predict consequences or risks based on available options. Despite its significance, the typical college course does not explicitly promote the skills that support causal reasoning. Over the past decade, we have developed and evaluated an introductory physics lab curriculum in which all activities are designed around the theory-evidence coordination (TEC) framework to advance subskills within three areas of reasoning, including control of variables, data analytics, and causal decision-making. This presentation will describe the lab curriculum and its design features that explicitly promote causal reasoning, including what we have learned about embedding question prompts and graphic organizers into pre-lab and in-class lab activities to promote this skill. The use of assessments, including the Inquiry in Scientific Thinking, Analytics, and Reasoning (iSTAR) assessment and E-CLASS, will be discussed along with research outcomes for the impact of the curriculum on targeted skill areas. Outcomes for impact based on gender, race, and first-generation college student will also be shared. Access to the full lab curriculum and iSTAR will be provided to those interested.

*Partially supported by the NSF IUSE 2110334.

(BG-02 10:24 AM-10:36 AM) I Contributed Talk (12 Minutes) I Assessing Scientific Reasoning in an Inquiry-based Physics Lab Course

Presenting Author: Lei Bao, The Ohio State University

Co-presenting Author | Lan Yang, The Ohio State University

Additional Author | Kathleen Koenig, University of Cincinnati

Scientific reasoning has been emphasized as a core ability of 21st century education. In our research, we have developed a validated scientific reasoning assessment instrument that is based on a coherent model and targets the wide-ranging skills required for 21st century learners. The assessment, referred to as Inquiry for Scientific Thinking, Analytics, and Reasoning (iSTART), integrates causal reasoning as part of scientific reasoning and operationally defines the skills and subskills that support the reasoning for knowledge development through scientific inquiry. To develop scientific reasoning skills, our team has also been developing an introductory physics lab curriculum, in which all activities are designed to advance subskills within three areas of reasoning, including control of variables, data analytics, and causal decision making. This talk will report the recent advancement in assessing the effectiveness of the new lab curriculum, especially on its capacity in developing the different subskills.

(BG-03 10:36 AM-10:48 AM) I Contributed Talk (12 Minutes) I Instances of Authentic Scientific Thinking in Labs

Presenting Author: Bradley McCoy, Azusa Pacific University

Additional Author | Daniel Hogue, Azusa Pacific University

Additional Author | Ryan Carroll, Long Beach City College

We recently redesigned the labs in our introductory calculus-based sequence to focus on teaching scientific thinking skills. In each lab project, students are given a research question and then they work with a group to design and execute an experiment. We also provide scaffolded instruction in scientific thinking skills as prelabs. In this talk, I will present preliminary results from qualitative research showing evidence of students implementing scientific thinking skills during their labs.

Session BH: PER: Teachers Supporting Teachers

Location: Mezzanine Level - Douglass **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Drew Milsom

(BH-01 10:00 AM-10:12 AM) I Contributed Talk (12 Minutes) I Responsiveness as a Guiding Principle in Creating a Vibrant Community of Practice of High School Physics Teachers

Presenting Author: Tim Stelzer, University of Illinois

Additional Author | Hamideh Talafian, University of Illinois

Additional Author | Eric Kuo, University of Illinois

Additional Author | Maggie Mahmood, University of Illinois

Additional Author | Morten Lundsgaard, University of Illinois

Teacher learning in professional Communities of Practice can be a double-edge sword. While such communities are beneficial for participating teachers, the diversity of background and teaching experiences can sometimes lead to power imbalances, which may undermine the effectiveness of these communities. In the Illinois Physics and Secondary School partnership program, we took a responsive facilitation approach in designing professional development experiences. This involved attending to teachers' needs and adapting the program instructions around those needs. Aligned with responsiveness approach and CoP framework, we involved high school physics teachers in the co-design and co-facilitation of a series of professional development sessions. This presentation reports teachers' perceptions of what efforts had the biggest impact with implications for physics teaching community.

This material is based upon work supported by the National Science Foundation under Grant NSF DRL 20-10188

(BH-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Physics Teacher Identity Development in a Physics Teaching Community of Practice

Presenting Author: Hamideh Talafian, University of Illinois at Urbana - Champaign

Additional Author | Tim Stelzer, University of Illinois at Urbana - Champaign

Additional Author | Eric Kuo, University of Illinois at Urbana - Champaign

Additional Author | Morten Lundsgaard, University of Illinois at Urbana - Champaign

Additional Author | Maggie Mahmood, University of Illinois at Urbana - Champaign

In this work, we present the journey of a high-school physics teacher-Kayla- over three years of her participation in a partnership program. Through this longitudinal case study, we showcase the identity development trajectories that Kayla undergoes during her participation in the program. Initially feeling like an imposter due to having a non-physics background, Kayla gradually gets recognition from the community and identifies herself as a successful physics teacher. The identity exploration of the case culminates when she advocates for teaching AP physics courses in her school and gets the approval to teach them. While Kayla attributes this change to the program, this work is an endeavor to shed light on multiple aspects of this development drawing from theories of science teacher identity development in professional development settings.

This material is base don work supported by NSF grant #2010188

Session BI: Impact of OPTYCs New Faculty Development Series: Supporting New TYC Faculty

Location: Grand Ballroom D **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Krista Wood

(BI-01 10:00 AM-10:48 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Impact of OPTYCs New Faculty Development Series: Supporting New TYC Faculty

Presenting Author: Krista Wood, University of Cincinnati Blue Ash

Co-presenting Author | Dwain Desbien, Estrella Mountain Community College

Co-presenting Author | Raeghan Graessle, Harper College

Co-presenting Author | Angela McClure, Estrella Mountain Community College

Co-presenting Author | Brittney VornDick, Durham Technical Community College

Co-presenting Author | Neda Zargar, Dallas College

The OPTYCs New Faculty Development Series (NFDS) for Two-Year College faculty is a 16-month immersion and mentoring program offered to faculty in their first six years of teaching full-time at a two-year college in the United States. The NFDS was built on the successful Two-Year College New Faculty Experience which had four cohorts. This panel of TYC faculty will share the impact of the original New Faculty Experience and the current New Faculty Development Series from the perspective of an OPTYCs co-PI, the NFDS coordinator, alumni leaders who participated as new faculty years ago, and current participants from the cohort who graduated this past weekend. We will be accepting applications for cohort 2 later this year. Interested in hearing more about this successful new TYC faculty program? Join us to learn more!

OPTYCs is sponsored by AAPT and funded by NSF grant #2212807.

This is the interactive PANEL on the approved list (application #12868), but does not show up in the options listed. The names listed above are the TYC faculty on the panel along with the submitter.

Session BJ: PhysTEC: Supporting Teacher Alums

Location: Grand Ballroom C **Time:** 19–10 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Adam LaMeei

(BJ-01 9:00 AM-9:48 AM) | | Empowering Educators: How the Knowles Teachers Initiative Nurtures Early Career Physics Teachers

Presenting Author: Shannon Morey, Knowles Teacher Initiatve, Abbott Lawrence Academy

The Knowles Teacher Initiative provides career-long support for physics teachers through its Teaching Fellows Program and the Knowles Academy. This session will discuss the core components of the Knowles Teaching Fellowship Program. New physics teachers—and those that support and prepare new physics teachers—should know about this opportunity that helps physics teachers thrive and become leaders from the classroom. We will then discuss the opportunities Knowles Fellows have once they have completed their fellowship and become Knowles Senior Fellows. This will include a discussion of the Knowles Academy Courses which are professional development opportunities led by Knowles Senior Fellows.

Session BL: Card Sort Activities in Physics Classes

Location: Grand Ballroom E **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Kelly O'Shea

Card sort activities can make a concept or unit more accessible to students by reducing the cognitive load and giving students some examples to make sense of as they solve the problem. They also can be a wonderful group-worthy task. In this interactive session, several physical examples of card sorts from high school physics classes will be available to see and try—as well ideas and discussion about creating your own card sort activity for your class.

Session BM: Teacher Share-A-Thon

Location: Concourse Level - Commonwealth A **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Tiffany Taylor

(BM-01 10:00 AM-10:48 AM) | | Teacher Share-a-Thon

Presenting Author: Tiffany Taylor

Teachers share best practices, lessons, lab ideas, and more at this session. All are invited to contribute. Designed for the K-12 educator.

Session BN: PER: Learning About Persistence

Location: Concourse Level - Commonwealth C **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** AJ Richards

(BN-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Growth Through Outreach: Results from a National Survey of Impacts of Informal Physics Programs on Undergraduate Students

Presenting Author: Jonathan Perry, University of Texas at Austin

Additional Author | Tatiana Eruhimova, Texas A&M University

Additional Author | Toni Sauncy, Texas Lutheran University

Additional Author | Susan White, American Institute of Physics

Additional Author | Jonan Donaldson, University of Alabama - Birmingham

The transition from being a novice to becoming a more expert physicist is one which is impacted by experiences both in and outside of the classroom. In recent years, studies have explored the development in physics identity, belonging, and career skills of students who facilitate and run informal physics programs. These results have shown a consistent, positive association between working with diverse audiences and students' self-perceptions of their physics identity, sense of expertise, communication skills, and more. Previous studies have been limited to a small number of institutions with a modest number of students in their data. Here, we present results from a national survey, distributed in spring 2023, which included both closed and open ended questions to sample a broad range of students' on their identity, belonging, mindset, and other related constructs, as well as information about how often, or not, they helped to run informal physics, or outreach, programs. Results from regression modeling from survey items, as well as network analysis from open ended responses will be discussed, highlighting major themes from relevant learning theories. We will also note similarities and differences between experiences based on institution type, gender, ethnicity, and other collected demographic factors.

(BN-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Staying or Leaving: A 5-year Study of Physics Major Persistence

Presenting Author: Anne Marie Porter, American Institute of Physics

What drives undergraduate students to persist in or drop a physics major? To answer this question, staff members at the Statistical Research Center (SRC) at the American Institute of Physics (AIP) conducted a 5-year longitudinal study between 2018 and 2023. We surveyed 3,917 students in the first week of their introductory college physics course and asked whether they wanted to major in physics. The 768 students who were considering a physics major were surveyed annually for 5 years. We compared the experiences of students who graduated with a physics degree and students who lost interest in a physics major. Among the students who left physics, most dropped physics during their first two years due to other interests or issues within physics courses, and they were more likely to report lower self-efficacy and less positive department climates. Underrepresented students who left physics reported less supportive relationships with physics professors and peers.

(BN-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Investigating the Impact of the Age of Exposure to Physics on Career Pursuit

Presenting Author: Jillian Ryan, The College of New Jersey

Additional Author | AJ Richards, The College of New Jersey

This project investigates how the age of first exposure to a formal physics class affects a person's desire to pursue a career in physics or a related field. We have administered a survey to college students at our institution, asking them about when they first took a physics course and their future career plans. In this presentation we will detail our findings and discuss whether the age of first physics exposure has an impact on a person's career pursuit and attitudes towards physics.

(BN-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Challenges Faced by Under-prepared Students with an Initial Desire to Get a STEM Degree

Presenting Author: Binod Nainabasti, Lamar University

Co-presenting Author | Cristian Bahrim, Lamar University

For more than 15 years, the Physics Department at Lamar University has offered a Preparatory Physics Foundation (PPF) course during each semester for intended STEM majors. Most students in the PPF class are first-generation students. They are underprepared to pursue a STEM major because they lack adequate counseling in high school, coming from educationally disadvantaged areas where many high schools do not offer physics courses or physics classes taught by physics-trained teachers holding a Physics degree. However, these students are highly motivation to get a STEM degree, also because living in an industrial area with numerous petrochemical plants, they are aware of the job opportunities as an engineer. From Spring 2016 to Fall 2020, 1017 students enrolled in the PPF course. Even though they completed the PPF course with a passing grade of C or better, nearly 20% of students did not continue with the Physics 1 core course, dropping their STEM major. This study explores the reasons behind the tough decision to quit a STEM major. Based on a questionnaire, we analyze the reasons behind dropping the STEM major for those students who received a good grade in our PPF and their initial expectations from learning physics.

Session BO: PER: Learning About Physics Identity Development, Self Efficacy and Belonging

Location: Lobby Level - Otis **Time:** 10–11 a.m. **Date:** Monday, July 8, 2024 **Moderator:** Amy Lytle

(BO-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Elements of a Physics Learning Assistant Program that Support Intersectional Physics Identity Development

Presenting Author: Xandria Quichocho, Texas State University

Additional Author | Simone Hyater-Adams, MEGA Imagination

Additional Author | Eleanor W Close, Texas State University

Studies show the negative impact that racism, sexism, homophobia and transphobia have on students who identify at the intersections of marginalized identities as they pursue STEM fields. The physics field is among the worst, being the most male-dominated of the sciences and one of the least racially and ethnically diverse. In spite of this, there are places where marginalized & minoritized physics students are able to find support and thrive. Research shows that these spaces are often found in Minority Serving institutions and are cultivated within things like physics clubs, learning assistant (LA) programs, and identity based organizations. In our research we use an identity lens to investigate the lived experiences of multiply marginalized physics students to better understand the ways their identities as physicists have developed throughout their time studying at an HSI; including time working as LAs in the Texas State Physics LA Program for the majority of our participants. Participants from TXST described the different environments where they felt that they thrived, particularly multiple positive impacts from the Physics LA Program. We analyze these narratives using the Critical Physics Identity framework to see in what ways LA participation overlaps with participants' racialized and/or queer experiences studying physics.

This work has been supported in part by NSF grants 1557405 and 1928596.

(BO-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Validating a Measure of STEM Students' Self-Efficacy for a Mixed Methods Research Design

Presenting Author: John Byrd, Michigan State University

Additional Author | Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Self-efficacy, crucial for academic achievement in STEM, is typically assessed using pre-post measurements from surveys. However, developing a way to assess in-the-moment impacts to students' self-efficacy would create many opportunities for further study and intervention. With this goal, we devised a mixed-methods approach combining the Experience Sampling Method (ESM) with individualized daily journal prompts. While rich, this design poses validation challenges. To address these challenges, we analyzed three ESM survey questions, indicative of task-level self-efficacy, for skewness. Deviations from normal distributions suggest that traditional validation techniques may not apply. We further examined the Pearson's coefficient of skewness for each item and participant that does not assume the normal distribution of data. We would expect that if all ESM survey items are aligned with self-efficacy then the skewness for each individual should be consistent across those items. In this talk, we will present the shifts in skewness between items and discuss the data from validation interviews that expand on our quantitative findings.

(BO-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Students Attribute Myriad Cultural Factors to Their Sense of Physics

Presenting Author: Victor Marcos, South Seattle College

Co-presenting Author | Larissa Carter, South Seattle College

Additional Author | Andrea L. Wooley, Michigan State University

Additional Author | Chloe Elise Hennessy, South Seattle College

Additional Author | Abigail R. Daane, South Seattle College

When students describe physics, they often associate this science with facts, formulae, and objectivity. In our research, we asked students to reflect on how their own experiences influence their sense of the nature of physics. We analyzed two year college students' written reflections from introductory physics courses. Students described their own familial, cultural, and professional backgrounds, as well as their instructors' identities and teaching methods, as impacting their perspective of subjectivity and objectivity in physics. Although culture is often ignored in STEM classes, the students can benefit from recognizing the interplay between personal and societal structures within physics learning and practice. By making space in class to compare and contrast physics culture with students' own experiences, we hope to show students that their individual background is key to shaping their learning and improving the often inequitable field of physics.

(BO-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Exploring the Growth in Sense of Belonging in a Modern Physics Course

Presenting Author: Daniel Pacheco, Florida International University

Additional Author | Geoffrey Potvin, Florida International University

Additional Author | Zahra Hazari, Florida International University

Sense of Belonging is an essential human motivation that has been shown to be a critical component in student's undergraduate career. In this talk, we report on an in-progress, mixed methods study to investigate factors that may shape Sense of Belonging for students during an upper division physics course. A 44-item survey measuring Sense of Belonging and Physics Identity constructs was administered to students in a student-centered Modern Physics course at the beginning and end of the semester. Confirmatory factor analysis was used to construct a measure of Sense of Belonging. Significant, positive gains in Sense of Belonging were seen in one particular semester. Follow-up interviews were conducted with three students from this class to understand how their experiences related to their shifts observed in their sense of belonging.

Session CA: Much More Than ChatGPT – AI-Tools for Learning and Teaching III

Location: Harbor Level, Harbor I **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Andrew Gavrin

(CA-01 2:00 PM-2:24 PM) I I Enhanced Learning Through the Integration of AI and Best Practices: A Randomized Controlled Study Comparing AI-Supported Pedagogy with Active Learning in Introductory Physics

Presenting Author: Gregory Kestin

Co-presenting Author | Kelly Miller

We present a randomized controlled study that compares learning gains and perceptions of AI-supported lessons in an introductory physics course to lessons that employ active learning with instructor and peer support. This study implements a generalizable approach to AI-supported instruction that offers a potential solution to long-standing challenges in STEM education. We find that introducing concepts to students using an AI-supported environment can lead to improved engagement, motivation, and learning gains.

(CA-02 2:24 PM-2:48 PM) I I HyperMInd – A Gaze-sensitive, AI-based Physics Textbook

Presenting Author: Yavuz Dinc

Adaptive learning systems can improve the quality of learning by capturing and interpreting learners' interactions with the learning material. Data sources such as log files or physiological measurements, e.g., observation of gaze metrics are used to gain deeper insights into user behavior. Our study investigates the integration of AI-based eye-tracking technology in the context of kinematics, focusing on graphical, mathematical and textual representations. By analyzing eye movement metrics, we aim to discover how these indicators can predict learning outcomes, leading to the development of an AI-driven, gaze-sensitive textbook. This approach aims to individualize learning by dynamically adapting the learning content to the individual's gaze behavior, thus providing a personalized learning experience. Subsequent steps include implementing the results from our first study in a gaze-sensitive intelligent physics textbook and investigating effective ways to provide adaptive support to students with learning difficulties.

Session CB: Highlights of Journals: TPT and Phys Rev-PER I

Location: Harbor Level, Harbor II **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator: Ga**ry White

CB-01 2:00 PM-2:24 PM) I I Using Math in Physics

Presenting Author: Edward Redish, U. of Maryland

Do you ever feel that your students don't seem to know the pre-requisite math for your classes, even though they did well in their math classes? Math in physics is different from pure math and learning that can be challenging for students. They have to learn to develop physical concepts and blend them with symbolic math.[1] This is harder than you might think. In my 8 short articles in *The Physics Teacher*,[2] I identify 7 tools students need to learn to build the blend — dimensional analysis, estimation, anchor equations (reading the physics in an equation), toy models, functional dependence, reading the physics in a graph, and telling the story. I explain both why these are so important and why so many students have difficulty with them in physics. In each article, I suggest a variety of instructional methods you can use to help students learn to use these tools, and, as a result, develop a strong physical intuition and learn to "think with math".
The supplementary materials for each article and the associated submissions to the Living Physics Portal[3] offer lots of relevant problems you can use in class and for homework.

1. E. Redish and E. Kuo, Language of physics, language of math: Disciplinary culture and dynamic epistemology, Science& Education, 24:5-6 (2015-03-14)
2. E. Redish, *Phys. Teach.* **59** (2021) 314–318; 397-400; 525–528; 599–604; 683–688; **60** (2022)
18–21; **61** (2023) 651–656.
3. The Living Physics Portal, https://www.livingphysicsportal.org/

(CB-02 2:24 PM-2:48 PM) I I Challenging Problems for Physics: 20+ Years of Delightful Braintwisters

Presenting Author: Boris Korsunsky, Weston High School

The column "Physics Challenges for Teachers and Students" published hundreds of braintwisters and reader-submitted solutions at TPT between 2000 and 2023. The solutions came from all over the world, and it was a pleasure to interact with so many problem-solving enthusiasts from every continent. In my talk, I will discuss the history of the column, my favorite problems, and the TPT articles inspired by some of the problems. The most prolific and successful solvers can expect personal shoutouts. In addition, I will discuss the role of problem-solving in high-school and undergraduate physics classes.

Session CC: Effective Practices in Educational Technology: Innovative Course Structures

Location: Harbor Level, Harbor III **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Anne Cox

(CC-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Responsive Instruction About Radioactivity Through Synthetic Groupwork

Presenting Author: Michael Hull, University of Alaska Fairbanks

Additional Author | Keshab R. Pokharel, University of Alaska Fairbanks

Last year we presented our first efforts in creating a synthetic groupwork-based learning module on radioactivity. In the module, individual online learners watch pre-recorded videos of a group of students discussing with each other as they go through a worksheet about radioactivity. For each question of the worksheet, the video pauses and prompts the learner for his or her own personal answer to the question. Although that was interactive instruction, it was not responsive, as the video that learners watch was unchanged by their responses. In this presentation, we will discuss our next efforts, the introduction of branching points in the video, creating a "choose-your-own-adventure" type of experience for the learner. We will present data in the form of student responses to questions in the module and conceptual surveys completed before and after the module, and we will compare this data to that collected last year with the linear (as in, no branch points) module. Our findings are relevant not only for instruction in radioactivity, but for online instructional content in general.

(CC-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Mastery-based Testing with Lockdown Browsers

Presenting Author: Luke Donforth, University of Vermont

The pandemic pivot to online education forced a rapid development of online educational resources and technology. In the post-pandemic return to in-person instruction, we took advantage of students' new familiarity and acceptance of online testing via lockdown browsers to implement a mastery-based testing protocol for students in introductory algebra-based physics (a large service course for the pre-med track). Students have multiple attempts outside of class to demonstrate mastery of the material via AI proctored multiple choice quizzes drawn from a large test bank. Student learning outcomes remain consistent with previous testing protocals, and student opinion strongly favors the new format.

(CC-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Nurturing Engagement in Learning through Course Structure, Resources, and Assessment

Presenting Author: Charles Ruggieri, Rutgers, The State University of New Jersey

In this talk, I present a mixed-methods investigation and subsequent course transformation within a two-semester, large-enrollment, calculus based undergraduate introductory physics course. Spurred by the Spring/Fall 2020 Covid-19 remote transition, we use the results of pre-Covid student surveys and interviews and follow guidance from the literature on high-structure course designs to develop and implement new course structures and resources within our course Learning Management System (Canvas) which include: a pre-lecture module with introductory videos, video quizzes with instructional explanations, and low-complexity tutorial assignment with low-stakes grading parameters. Additionally, I describe exam preparation resources including optional exam-preparation modules, mandatory (graded) online mini-exams with follow-up opportunities to earn back credit, and more. Furthermore, I walk through my use of a popular LMS integration, PlayPosit, to engage students in videos for exam preparation, formative assessment, and to lower the barrier to student engagement in the lecture experience. Recent post-transformation student survey data suggest students greatly value the course structure, assessment practices, and the expanded course resources as helpful to their learning experience and reduction of anxiety regarding course assessments. Students also comment specifically and positively on the course structure, expanded resources, and assessment practices.

(CC-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Personalizing Instruction in Problem-Solving through Web-based Interactive Video-Enhanced Tutorials (IVETs)

Presenting Author: Kathleen Koenig, University of Cincinnati

Additional Author | Alexandru Maries, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology - Emeritus

Meeting students' diverse learning needs poses significant challenges, especially in large enrollment courses or those involving students with wide ranges of abilities. To address this challenge, we created a comprehensive suite of over 30 web-based interactive video-enhanced tutorials (IVETs) designed to provide personalized instruction in problem-solving. These tutorials offer expert-like problem-solving approaches for specific topics, such as angular momentum, covering most chapters taught in a two-semester introductory physics course. The IVETs feature video narration by a live instructor, with branching multiple-choice questions to actively engage students. Feedback and hints are provided to foster learning, simulating the personalized support experienced during office hours. This presentation will showcase one of our IVETs and the research outcomes that demonstrate its impact on students' development of essential skills. Best practices for effective implementation will be shared, including how IVETs can be assigned to support end-of-chapter homework exercises. IVETs are freely available for student use at compadre.org/IVET or they can be embedded directly into Learning Management Systems using SCORM packages, where a completion grade can be assigned. IVETs require minimal instructor effort and support remote, hybrid, and face-to-face courses.

Supported in part by DUE-1821391 and DUE-1821396.

Session CD: Innovations in Teaching Beyond Introductory Physics I

Location: Lobby Level - Marina Ballroom II **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Tonya Coffey

(CD-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Teaching Magnetism with Bivectors: Deeper Concepts, Distinct Fields, and No Right-Hand Rules

Presenting Author: Steuard Jensen, Alma College

Imagine never again watching a student struggle to master yet another right-hand rule, never again seeing them jumble up the very different rules for electric and magnetic field vectors, never again worrying that someone will accidentally use a left-handed coordinate system. Imagine them understanding why relativistic electromagnetism involves an antisymmetric tensor, or knowing how to describe a magnetic interaction in purely two dimensions (or in four or more) where the cross product isn't defined. We won't get there overnight, but it's all possible if we describe magnetism as a bivector field. Instead of vector arrows, bivectors can be visualized as "tiles" with area and orientation whose components form an antisymmetric matrix: the tiles of a bivector field thread along magnetic field lines like beads on a string. Even though they're less familiar today, in most ways bivectors are no harder to understand than vectors and cross products, and they can be introduced with rotational physics well before students must apply the idea to magnetic fields. Adopting this one easily visualized concept (without complicated additional structures like differential forms or geometric algebra) can address all those challenges, and some worthwhile first steps require very few changes to traditional instruction at all.

(CD-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Experiences with a New Quantitative Particle Physics Course for Second-year Physics Students

Presenting Author: Brandon Eberly, University of Southern Maine

Particle physics is typically an advanced elective in the undergraduate physics curriculum, if it is offered at all, due to the advanced mathematical toolset needed to perform amplitude calculations and explore the symmetries of the Standard Model. In response to this, I have created a new quantitative particle physics course that provides a broad overview of the field and covers both theoretical and experimental perspectives. The course is accessible to second-year physics students who have taken a calculus-based introductory physics sequence and a first course in special relativity and quantum mechanics. The topics include particle phenomenology with Feynman diagrams, relativistic particle kinematics, conservation laws, particle detection, and an introduction to cross section and lifetime calculations. In this talk, I will describe the curriculum and reflect upon my experience teaching this class for the first time at the University of Southern Maine.

(CD-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Assessing Learning in a Flipped Upper-level E&M Classroom

Presenting Author: Beth Parks, Colgate University

Additional Author | Ramesh Y Adhikari, Colgate University

Using lecture videos and textbook readings to share course content with students allows class time to be used for problem solving. How does this non-traditional course structure impact student problem-solving capability? One might hope that working problems in class with the instructor present to answer questions will allow students to become better problem solvers. However, my observations of students' problem-solving behavior, including rushing through solutions in order to finish in class, demonstrating unwillingness to work problems outside of class, and neglecting the steps of checking their work, makes me worry that they are not learning essential problem-solving skills. I am comparing problem-solving skills as demonstrated on matched exam problems from previous years' instruction in order to assess the impact of teaching in a flipped classroom.

(CD-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | An Iconic Problem Analysis of the Undergaduate Physics Major

Presenting Author: Juan Burciaga, Colorado College

Iconic problems share many of the characteristics of threshold concepts (transformative, integrative, bounded, …). But the iconic problems of the introductory physics curriculum are frequently revisited in increasing depth and complexity throughout the physics major. The talk presents an analysis of a representative physics major in terms of the iconic problem paradigm with a focus on the application of the paradigm to the upper-level curriculum of the physics core courses as defined in a representative physics major. Is the paradigm a useful tool to reimagine the physics major?

(CD-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | "Things" That Go Faster Than Light: Getting Students Talking About Wave Speeds

Presenting Author: Gabriel Spalding, Illinois Wesleyan University

Before beginning discussions of what we might mean by the speed of something that does not have "a" position, it might be useful to return to something students may feel we "swept under the rug" previously, namely that "the" position of objects considered in earlier physics instruction was, in fact, a statistical construct (one among many). Continuum mechanics, including descriptions of waves more explicitly notes that there are distributions of energy and momentum, with correlations between different points. This talk shares a variety of prompts aimed at getting students talking about wave speeds, based on recent experimental examples of "things" that go faster than light, including different types of photonic booms, discussion of the Gouy phase shift and bottle beams, accelerating light in free space, and superluminal polarization currents. Some of these topics can be introduced at the introductory level.

Session CE: Learning from the Eclipse II

Location: Lobby Level - Marina Ballroom III **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Ann Schmiedekamp

CE-01 2:00 PM-2:24 PM) | | Modern Eddington Experiment MEE2024

Presenting Author: Toby Dittrich, Portland Community College

The goal of the Modern Eddington Experiment (MEE2024) is to make the most precise measurement ever of the gravitational deflection of stellar positions near the Sun during a total solar eclipse using ground-based optical images, and by so doing, we seek to demonstrate the nature of the 1/R relationship for deflected stars. Fourteen observing teams will perform the MEE2024 during the total solar eclipse crossing North America on April 8, 2024. Feasibility was shown in the 2017 total solar eclipse, with the expectation that the 2024 results will be orders of magnitude more precise. This is primarily due to faster cameras, a longer totality, and multiple data sets. A computer program is being developed to semi-automatically complete the data analysis. This program will include corrections for optical distortion and finding accurate star centroid locations near the Sun, especially between R = 1-2 where the deflection is large. This should result in a final deflection curve accurate enough to verify Einstein's formula. The results from the MEE2024 eclipse project will be announced.

(CE-02 2:24 PM-2:48 PM) | | Solar Eclipses as Tools for Atmospheric Studies

Presenting Author: Natalia Lewandowska, SUNY Oswego

Solar eclipses are a rare enough event that most people only witness them once during their life times. When the Moon covers the Sun interesting changes happen to the atmosphere of our planet. Participating for the first time in NASA's Nationwide Eclipse Ballooning Project (NEBP), SUNY Oswego sent several students and professors from the Physics and Astronomy as well as the Atmospheric and Geological Sciences Department to New Mexico in October 2023 to watch the annual solar eclipse and send sondes up to the stratosphere of our planet to study changes in the wind speed, chemical composition and temperature before during and after a solar eclipse. In this presentation we will report about our findings from this annual solar eclipse in addition to the total solar eclipse that will be visible from Oswego, NY in April 2024. We will give an outlook on our data, the current results and report about the communications with other schools and the public.

Session CF: Teaching Quantum Mechanics to Promote Workforce Development I

Location: Lobby Level - Marina Ballroom IV **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** James Freericks

(CF-01 2:00 PM-2:24 PM) I I Photon Labs for Teaching Quantum Physics

Presenting Author: Enrique Galvez, Colgate University

Photon labs developed over the last 20 years have produced a curriculum of laboratory exercises that illustrate applications of quantum algebra and highlight non-classical aspects of quantum physics. A quantum workforce requires experiences where students can see how the theoretical quantum operations learned in class (quantum states, operators, measurement) are applied to real systems. Students must also understand concepts critical to quantum technologies, such as superposition, indistinguishability, entanglement and non-locality. They differ from classical approaches in significant ways, and laboratories make them all vivid situations. The light source for the laboratories entails generating and using photon pairs produced by spontaneous parametric down-conversion. It can be put together in-house or bought commercially. Experiments can be tailored to the approach that is being taught. The labs are less about skill building and more about designing how to take data and its analysis. Complexity and expense force the use of a single setup, with optional automated components. This creates a new laboratory paradigm where student groups do labs sequentially with the same setup.
Funded by NSF grant PHY-2011937

(CF-02 2:24 PM-2:36 PM) I Contributed Talk (12 Minutes) I Experiential-learning Techniques in Teaching Optics and Photonics for Better Understanding Quantum Physics

Presenting Author: Cristian Bahrim, Lamar University

Additional Author | Binod Nainabasti, Lamar University

Twenty years ago, a senior level Optics course was introduced in our Physics curriculum. The initiative was triggered by the lack of advanced physics courses with a laboratory component. Quickly this course become popular among electrical engineers and chemistry majors, dragging in Physics several dual majors, mainly because of two experimental topics: energy transfer through fiber optics and spectroscopy. After five years, Optics reached 36 students enrolled, both graduates (two-thirds) and undergraduates (one-third). This course helped to increase the enrollment in Physics. Our graduation rate went up from 2-3 graduates per year before 2012, to two digits number for several years after 2014, until close to Covid-19 pandemic. This course offers hands-on experience on topics in-demand by our local workforce industry, such as optical analysis of gaseous emissions by industrial towers in refineries and petrochemical plants using optical fibers who carry spectral information to optical detectors. The reason why Optics became a pivotal course in Physics is for offering a better understanding of quantum physics through hands-on experience and practical knowledge for a modern workforce. We report statistical data and best practices adopted in teaching Optics/Photonics through hands-on experience that makes Optics labs to have a positive impact on students' understanding of Quantum Physics.

(CF-03 2:36 PM-2:48 PM) I Contributed Talk (12 Minutes) I Implementation of a Curriculum of Experiments for a Quantum Teaching Laboratory

Presenting Author: Danyel Cavazos-Cavazos, The University of Chicago

Additional Author | Hannes Bernien, The University of Chicago

Additional Author | Alexander A. High, The University of Chicago

Given the growing interest in quantum information science on both private and public sectors, higher-education institutions are now in the process of developing new courses and programs to accommodate for the expanding demands of the quantum workforce. We have implemented a senior-level laboratory course that gives undergraduate students a chance to develop hands-on experience on three different state-of-the-art quantum engineering platforms, including entangled photons, ultracold atoms and nitrogen-vacancy centers. Teaching practical and technical skills related to quantum engineering has allowed our students to either join the quantum workforce directly, or be better prepared for their future graduate careers. We will discuss the execution of the experiments in terms of equipment, and how we organize the class material to guide the learning process with a student-first approach.

Session CG: Effective Practices for Developing Scientific Reasoning and Decision-Making Abilities II

Location: Harbor Level - Lewis **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Troy Messina

(CG-01 2:00 PM-2:12 PM) I Contributed Talk (12 Minutes) I Developing Evidence-based Decision-Making through "Reacting to the Past"

Presenting Author: Jill Macko, Eastern Nazarene College

In this presentation, I'll discuss our experience implementing the game, "Reacting to the Past: Climate Change in Copenhagen, 2009," in one of ENC's general education courses for the past ten semesters. This active-learning pedagogy involves students exploring the international climate conference of 2009 as an assumed role, and it serves as a platform for students to practice evidence-based decision-making as members of a diverse group. The game requires students to consider the evidence for and against climate change and to collaboratively create and agree upon a solution. Throughout, they must consider diverse perspectives, including within the scientific community. Students have consistently self-reported growth in collaboration and communication skills, their capacity for respectful engagement with diverse viewpoints, as well as adeptness in the construction and evaluation of solutions to complex social issues. Further, students frequently reference the game in end-of-semester evaluations as a highlight, underscoring its significance in their learning journey.

(CG-02 2:12 PM-2:24 PM) I Contributed Talk (12 Minutes) I Creativity in the Science and Engineering Classroom and Beyond

Presenting Author: James Masi, University of Southern Maine

Co-presenting Author | Robert M Sanford, Univ Of Southern Maine

Creativity is a skill not confined to art studios, think tanks, or music rooms. We cover the multifaceted world of fostering creativity within physics, the sciences, and mixed-discipline settings. Can we change our creativity by overcoming habits that impede it? We explore practical strategies, real-world applications, and the vital impact of creativity on learning and post-education problem solving covering several key aspects:

- Defining Creativity: Creativity extends beyond mere paintings and poems. Exclusive of a future in STEM or the arts, students benefit from nurturing their creative thinking skills.

- Risk-Taking and Resilience: Creativity is at its best when we take risks, embrace experimentation and learn from mistakes, contributing to resilience and growth.
- Real-World Problems: We can enhance creativity when we explore ways to integrate real-world problems, classroom activities, and design templates.
- Collaboration and Cross-Discipline: Creativity flourishes in collaborative environments by utilizing the power of cross-fertilizing knowledge, people, and ideas.

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(CG-03 2:24 PM-2:48 PM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Unleashing Physics Understanding Through Dimensional Analysis: An Instructors Guide

Presenting Author: Michael Peterson, Triangle Math and Sci Academy

Prepare to embark on an exciting journey into the realm of theoretical physics with dimensional analysis! Dimensional analysis is an indispensable tool used by physicists, from astrophysics to the intricate world of condensed matter and high-energy. While commonly used to verify physics equations during problem-solving, its true power lies in simplifying complex physics using basic algebraic techniques. Join us for this session to discover how this method can improve your students' understanding of physics and empower them to craft mathematical expressions and bold hypotheses ready for experimental validation. According to student surveys, students feel that learning dimensional analysis is straightforward and leads to higher understanding and achievement. Research supports that embedding dimensional analysis within each unit of the physics curriculum results in a strong effect size on standardized physics tests. Session participants will not only grasp the essence of dimensional analysis but also learn how to seamlessly integrate this technique into their curriculum. After exploring a sample unit, we will craft our own lesson plans incorporating dimensional analysis. Get ready for your students' achievement to soar!

Session CH: PER: Instruction and Curriculum

Location: Mezzanine Level - Douglass **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Danielle Maldonado

(CH-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Investigating How Interactive Lecture Tutorial Supports Student Learning

Presenting Author: Al Snow, University of Washington, Seattle
Additional Author | Charlotte Zimmerman, University of Washington, Seattle
Additional Author | Paula R. L. Heron, University of Washington, Seattle

The Tutorials in Introductory Physics, developed at the University of Washington, are designed to be used in small classroom sections and have been shown to be helpful for students developing conceptual physics reasoning. In recognition of the high-resource demand that small classrooms require, the Physics Education Group at the University of Washington is in the process of adapting the tutorials to be (a) more modular, and (b) for use in interactive, lecture classrooms. These materials have been developed and piloted for the last several years in the algebra-based physics courses at the University of Washington. In this presentation, we present results from a multi-year study into how the tutorials help support student learning. This work is supported by the National Science Foundation, under grant No. DUE-1821032.

(CH-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Successes and Challenges Implementing Tutorials in Introductory Physics in a Variety of Environments

Presenting Author: Sarah (Sam) McKagan, Alder Science Education Association
Additional Author | Adrian Madsen, Alder Science Education Association
Additional Author | Lauren Bauman, Alder Science Education Association

We have conducted research with physics faculty members implementing Tutorials in Introductory Physics to learn about how Tutorials work in a variety of environments, the implementation challenges faculty face, and the types of support that faculty need to implement them effectively. We report on the results of this research, and on community activities designed to support Tutorials Implementers.
This work is supported by NSF DUE 1821032.

(CH-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Layers, Spirals, and Extras: Refining the Flipped Classroom Approach

Presenting Author: Deepthi Amarasuriya, Northwest College

My "Layered Approach" helps students of varying skill levels, academic backgrounds, and personal schedules manage their algebra- or calculus-based introductory physics sequence effectively. This novel method is informed by pedagogical philosophies of the Flipped Classroom, Active Learning, Bloom's Taxonomy, Collaborative Communication, and Universal Design for Learning. The approach has built-in flexibility to allow each student to engage with different topics at their comfort level. Material presented in three self-contained layers that require minimal cross-referencing leaves class time and mental energy for calculations. Quizzes serve as exam review; they are carefully structured to hone critical thinking, and to guide students systematically through the requisite steps. Students have expressed satisfaction with the transparency of expectations, and the emphasis on problem solving.

(CH-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Implementing and Evaluating ISLE in Introductory Algebra-based Courses

Presenting Author: Amin Bayat Barooni, Georgia State University

I implemented Investigative Science Learning Environments (ISLE)[1] in my studio classes. Over two semesters, I employed ISLE in an introductory algebra-based studio class, characterized by its diverse student population majoring in Biomed, Biology, and computer science. This instructional approach induced a transformation in students' conceptual understanding and attitudes, assessed through pre and post-assessment tests. Additionally, I observed improvement in their scientific skills. While the advantages of employing ISLE were apparent, its integration presented challenges for me, particularly in the need to train teaching assistants (TAs), and revise and regrade student assignments. Additionally, students who had adapted to traditional teaching methods faced hurdles in transitioning to an innovative approach like ISLE. This challenge was more pronounced compared to my students' challenges in my interactive lecture classes. Despite this initial resistance, the benefits became evident, contributing to a positive student experience. I aim to share both the successes and challenges encountered while implementing ISLE, with a focus on curriculum redesign, TA training, and student adaptation. Furthermore, a comparative analysis will be presented by juxtaposing the outcomes of the studio class, emphasizing ISLE pedagogy, with those of a simultaneously conducted lecture class where I focus on Think/Pair/Share [2] and Just-In-Time Teaching [3] methods.

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(CH-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | Utilizing the Cognitive Theory of Multimedia Learning Through a Course Workbook: A Practice Spanned Over a Decade and Three Countries within a Range of Courses

Presenting Author: Ajith Rajapaksha, University of Arizona

The cognitive theory of multimedia learning (CTML) highlights that effective learning requires the utilization of multiple sensory channels and asserts that learners must participate in integrating individual sensory information to form personal conceptual models. I use a physics workbook in my teaching to enforce the CTML. In this practice, the workbook exercises facilitate the space for integrating sensory information provided in the workbook itself and in-class activities to construct personal concept models. The workbook exercises maintain a sequence that can be interpreted as the Socratic process of establishing new knowledge by answering a sequence of questions based on already known concepts and definitions. Sometimes, the essence of the sequence would not become significant untill later. Then the students are encouraged to summarize the process. I first used a workbook in 2016 at Purdue University. The practice has continued and I have used it in the intro. mechanics, thermodynamics, intro. atomic and nuclear physics, modern physics and relativity, quantum mechanics (spring 2024 in China), theoretical mechanics, mathematical methods and differential equations courses. Some workbook exercises are used as pre-class assignments and the subsequent exercises will be attended in-class. Additional homework exercises are also included. Closing each workbook chapter students would prepare and include a chapter summary.

Session CI: TYC Initiatives in the Classroom and Beyond

Location: Grand Ballroom D **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Dean Stocker

(CI-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | OPTYCs New Faculty Development Series – What is it? Why it matters!

Presenting Author: Krista Wood, University of Cincinnati Blue Ash

The OPTYCs New Faculty Development Series (NFDS) for Two-Year College faculty is a 16-month immersion and mentoring program offered to faculty in their first six years of teaching full-time at a two-year college in the United States. We will share where the OPTYCs New Faculty Development Series started, what it involves, and how it supports new two-year college faculty. The first cohort graduated this past weekend and will be sharing their experiences. Join us to hear the impact the project is making for NFDS participants and their students.

OPTYCs is sponsored by AAPT and funded by NSF grant #2212807.

(CI-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Adding Discourse to Physics Classes

Presenting Author: Timothy Jones, Craven Community College

This talk will outline experiences from replacing much of the lectured content of both conceptual and calculus-based physics classes with discussion-based classes. From trying this replacement, I have some tips for interacting with students, how I prepare for a more interactive class, and ideas about when it is best to let students stay in control of the class verses when to interrupt. I'll also talk about students' attitudes and reactions to the more interactive class style.

OPTYCs is sponsored by AAPT and funded by NSF grant #2212807

(CI-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Student Feedback and Assessment Results of Implementing Active Learning Activities in Introductory Physics at Two-Year College

Presenting Author: Scott Sawyer, Pima Community College

I will be presenting a summary of the activities I introduced in my calculus-based mechanics courses at Pima Community college. Activities included student whiteboarding, Interactive Lecture Demonstrations, learning reflections, student presentations, and discourse management. I will be sharing anonymous feedback from students about the effectiveness of the various activities. I will share the results of the Force Concept Inventory Assessment given to these sections. The two sections of Mechanics courses were taught in a studio format with lecture and lab integrated and contained 24 and 28 students at the start of the semester.

(CI-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Examining the Cause and Effect in a Rube Goldberg Machine-Revamp

Presenting Author: Brittney VornDick

Students throughout a semester have to design and apply physics concepts to their own hypothetical Rube Goldberg Machine. They must computationally analyze the interaction as objects move through their machine, not only do they need to calculate the time, they also need to examine how one object collides with another affects the trajectory in the next step. It is a project for the engineering physics Mechanics course and is designed to embody all of bloom's taxonomy. This project has undergone a couple of modifications over the course of four years which the newest version (portfolio style) will be addressed.

(CI-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | Integrating Computation in a Two Year College Environment

Presenting Author: Chris Orban, Ohio State University / STEMcoding Project

I teach at a regional campus of Ohio State University and I integrate computer programming activities into my introductory physics courses with a "physics of video games" theme. These activities come from the STEMcoding project and often they include features to give the student a little green check or red X depending on whether they complete a coding task correctly. These activities are described on the STEMcoding youtube channel (http://youtube.com/STEMcoding) which frequently features women and underrepresented groups in STEM. I give some personal thoughts on doing coding and physics in a two year college environment and mention some of the academic articles I have written on the topic.

Session CJ: An Introduction to the STEP UP Lesson

Location: Grand Ballroom C **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Bree Barnett Dreyfuss

(CJ-00 2:00 AM-2:48 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | An Introduction to the STEP UP Lesson

Presenting Author: Kori Bowns-Kamphuis, Lindblom Math and Science Academy

Co-presenting Author | Catherine Garland

Co-presenting Author | Praisy Poluan

Come learn about the two NGSS-aligned STEP UP lessons that increase the physics identity of women and historically marginalized students. The Careers in Physics lesson introduces students to the varied careers one can have after earning a bachelor's degree in physics, particularly those that help solve societal problems. Students assess their personal values in relation to a career in physics, examine profiles of professionals with physics degrees, and envision themselves in a physics career. The Women in Physics lesson guides students through a conversation about unconscious bias, students practice their data analysis and scientific discourse skills while learning more about who has traditionally studied physics both in the United States and around the world. Students examine the conditions for women in physics and discuss gender issues with respect to famous physicists, gendered professions, and personal experience to neutralize the effect of stereotypes and bias.

This work is supported by the National Science Foundation under Grant Nos. 2300607,1720810, 1720869, 1720917, and 1721021 and the Gordon & Betty Moore Foundation DOI: doi.org/10.37807/GBMF11451

Session CK: Alternative Assessment

Location: Concourse Level - Commonwealth B **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Marianna Ruggerio

(CK-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Collaborative Assessments in High School Physics

Presenting Author: Emma Mitchell

One of the hallmarks of student-centered physics pedagogy is collaborative sense-making and problem-solving. Through group work, students combine mental resources to solve problems using perspectives and peer feedback that would not be available to them if the work were done only individually, and collaborative problem-solving processes build confidence for students who are systemically underrepresented in physics. If group work is a core component of your classroom culture, then why not incorporate elements of collaboration into your assessment practices, too? This talk will discuss several strategies for designing assessments that use the advantages of collaborative work while still evaluating students on skills that they demonstrate individually, from 9th-grade physics to the AP level in an all-girls' high school.

(CK-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Non-traditional Grading Schemes: Why to Use Them and How to Manage Them

Presenting Author: Joshua Rutberg, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Traditional gradebooks and Learning Management Systems are generally only built to accommodate traditional percentage grades but there is growing interest in and evidence of the effectiveness of grading schemes which do not rely on percentages. In this talk we will share some alternative grading schemes and share some of the reasons why many teachers are rethinking how they grade in order to improve student outcomes, increase motivation, and promote equity in the classroom. Beyond this, we will share how we have used spreadsheet applications available to all in order to manage our own grades and how others might use them to fill the gap left by LMSs which cater only to traditional grading. Our hope is to provide anyone who wants it a starting point to rethink how they grade their own students.

(CK-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Implementing Retrieval Practices in Physics

Presenting Author: Marianna Ruggerio, Auburn High School

Implementing retrieval practices in the classroom enhances student learning by regularly requiring students to pull information from their long term memory, rather than cramming information into their memory. There is also an added benefit of providing students with the opportunity to reflect on what they do, in fact, remember and which details may still be murky in order to have a more accurate judgement of their learning without the stress of a formal assessment setting. This talk will discuss several retrieval exercises implemented in on-track and AP Physics classrooms and the benefits for student learning and confidence.

Session CL: Cross-disciplinary Learning in High School Physics Classrooms II

Location: Grand Ballroom E **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Susan Meabh Kelly

CL-01 2:00 PM-2:24 PM) | | Comparing Different Types of Computational Thinking to Teach Kepler's Third Law

Presenting Author: James Newland, Bellaire High School

Integrating computational thinking into physics courses can allow students to learn physics while also learning to use computing tools and techniques useful in other academic contexts. Computational thinking practices involve computer programming, simulations, and reducing and visualizing data. Pedagogical techniques developed by computer science educators to reduce cognitive load on students can be leveraged when using computational thinking in a physics context. See how different computational thinking practices could be used to teach Kepler's Third Law. Different uses of spreadsheet software and computer programming will be discussed, allowing students to reduce and visualize data, create models of orbits, and perform linear regressions to determine the mass of a central star in an exoplanet system using authentic data from the Kepler spacecraft. Some examples of modeling Kepler's Laws using computer programming will also be discussed.

(CL-02 2:24 APM-2:48 PM) I I Throw Things Down the Stairs and Call it Science – A Design-Build Concussion Project

Presenting Author: Mike Florek, Glenvar High School

In a given physics classroom, the odds are good that at least one student has had a concussion or has a friend who did. Many students participate in sports or activities with a risk of head injury. This problem-based lesson tackles concussion prevention in football and bridges the disciplines of physics and engineering. Students are challenged to design their own helmet padding using upcycled packing materials. The test rig is currently a foam head-form with an embedded accelerometer. Students must complete a set of blueprints, construct the designs, and then test for efficiency. I will walk you through the phases of the project, providing insight from missteps and successes, and share adjustments I will try in the next iteration. We will step through a dry run of the data collection with old designs.

(CL-03 2:48 PM-3:00 PM) I Contributed Talk (12 Minutes) I My Brain Hurts – A Student-Driven Inquiry into Biomechanics and Neuroscience

Presenting Author: Mike Florek, Glenvar High School

In a given physics classroom, the odds are good that at least one student has had a concussion or has a friend who did. Many students participate in sports or activities with a risk of head injury. This inquiry-based research project flips the classroom, with students as the experts, and connects physics with human anatomy. Anatomy students are introduced to impulse and momentum. Physics students get a crash course in brain physiology. Students are randomly sorted into groups of three or four and given a brain injury topic. Students then participate in a RAFT (Role – Audience – Format – Topic) brainstorming session, in which they invent roles (e.g. Rocket Scientist), audiences (e.g. Kindergarten), and formats (e.g. Game Show). Over several days, students scour academic papers, interviews, and other primary-source documents. In the end, they combine their serious research with the not-so-serious RAFT for a memorable and engaging presentation.

Session CM: New Community Resource: Critical Race Theory and Physics Education

Location: Concourse Level - Commonwealth A **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Amy Robertson

In this session, we will give an overview of a new community resource: a series of manuscripts about Critical Race Theory and physics education, published on PER Central. Authors of manuscripts will introduce their pieces, and editors of the serial will share aims and themes. Participants will be invited into a community conversation about themes and questions. (Note: This is a session that prioritizes community care, including wearing a mask throughout the session unless there is a medical reason not to do so.)

Session CN: PER: Access and Inclusion

Location: Lobby Level, Stone **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Jim Kernohan

(CN-01 2:00 PM-2:12 PM) I Contributed Talk (12 Minutes) I Exploring Access in Computing and Active Learning Course Materials

Presenting Author: Theodore Bott, Michigan State University

Additional Author | Daryl R McPadden, Michigan State University

Over the last several decades, computing and active learning have been incorporated into physics and other STEM degree programs. While research has examined the learning gains, attitudes, and many other aspects of these classrooms, there has been little work done to understand these classrooms through an accessibility lens. With up to 20% of postsecondary STEM students identifying as disabled, combined with the fact that computing and active learning techniques pose unique barriers for disabled students, it is important that we begin investigating the accessibility of computational and active learning settings. In this work, we present results of a document analysis of CMSE 201, a large-scale introductory applied data science course at Michigan State University that teaches python programming in an active learning environment via Jupyter notebooks. Since the ability to engage with a course's curricular materials comprises a significant portion of the course's overall accessibility, we conducted a document analysis which sought concrete examples of alignment and unalignment between the course's curricular materials and accessibility standards like the Universal Design for Learning (UDL) framework. From this analysis, we make recommendations to curriculum designers and instructors on ways to design for better accessibility in their respective computational & active learning environments.

(CN-02 2:12 PM-2:24 PM) I Contributed Talk (12 Minutes) I Physicists' Attitudes Towards Career Viability Vary by Disability and Career

Presenting Author: Daniel Oleynik, University of Central Florida

Additional Author | Erin M Scanlon, University of Connecticut - Avery Point

Additional Author | Constance M Doty, University of Central Florida

Additional Author | Jacquelyn Chini, University of Central Florida

Students with disabilities represent a significant fraction of physicists, but institutions do not currently adequately support them. We surveyed 250 physicists at national conferences and email listserv to investigate their knowledge about and attitudes toward disability. This survey, called the Disability and Physics Career Survey, asked physicists to categorize disabilities by impairment type (e.g., physical/mobility, health, cognitive, visual, hearing, and emotional/mental health), and asked them to rate whether certain careers, such as teacher and engineer, were viable or not viable for individuals with different impairments. This study focuses on perceptions of physics career viability for disabled people. We use Cochran's Q to analyze whether participants' perceptions of career viability varied across careers within a specific impairment and also across impairments within a specific career. We will interpret our findings to offer possible themes in physicists' beliefs about disability and career viability with suggestions for mentors to identify their own inclusive beliefs as well as challenge their exclusionary beliefs.

(CN-03 2:24 PM-2:36 PM) I Contributed Talk (12 Minutes) I Improving Access in Group-based Courses for Students with ADHD

Presenting Author: Daryl McPadden, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Harsna Chahal, Michigan State University

Additional Author | Alex Reynolds, Michigan State University

Over the last several decades, active learning has been incorporated into many physics courses, often requiring students to work in groups on problem solving. While active learning has been shown to be beneficial for students on average (in conceptual understanding, attitudes, self-efficacy), very few studies have examined the experiences of disabled students in active learning courses. In this work, we present a case study focused on the experiences of three students with ADHD and their experiences in group-based STEM courses. From a series of four interviews with the participants, we highlight the course structures and relationships that had an impact on these students. From these results, we make recommendations to instructors and course designers for strategies to improve access in their classrooms.

Session CO: PER: Investigating the Experiences of Women in Physics

Location: Lobby Level - Otis **Time:** 2–3 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Jennifer Pursley

(CO-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Examining the Role of Family in Women's Engagement and Success in Physics

Presenting Author: Laura Akesson, George Mason University

Additional Author | Jessica L Rosenberg, George Mason University

Additional Author | Nancy Holincheck, George Mason University

Additional Author | Benjamin W Dreyfus, George Mason University

Although some progress has been made over the last 50 years, physics still has one of the largest gender gaps of the sciences. The gap has been attributed to a variety of causes, including aspects of culture, early exposure to STEM, and gender-based psychologies, but few studies approach this issue centering the perspectives and experiences of women in physics. We focus on the role of family to understand the engagement and success of undergraduate women in physics. In this presentation, we will discuss our qualitative analysis of 120 surveys and 31 interviews of undergraduate physics students (92% identifying as female). We relate our findings to recent established STEM- and physics identity frameworks (including Carlone & Johnson and Hazari), and present new aspects emerging from our data.

(CO-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | How Our Role as Instructors Shapes Women's Experiences in Undergraduate Physics Programs: A Comparative Analysis of Three Physics Departmental Cultures

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

This investigation compares the physics departments at three institutions using interview data from undergraduate women in physics. Using synergistic frameworks such as Standpoint Theory, Domains of Power, and the Holistic Ecosystem for Learning Physics in an Inclusive and Equitable Environment (HELPIEE), we analyze how those in the position of power, e.g., instructors, can play important roles in establishing and maintaining safe, equitable, and inclusive environments for students. This is especially important for historically marginalized students such as women and ethnic and racial minority students in physics. The three studies include Johnson's 2020 study using Domains of Power to investigate physics identity of students and faculty at a small predominantly White liberal arts college. The next study is Santana and Singh's 2023 study which utilized Standpoint Theory to understand the experiences of undergraduate women at a large predominantly White research institution and revealed a masculine physics culture. The third study is Santana and Singh's 2024 study which combined Standpoint Theory, Domains of Power, and HELPIEE frameworks to investigate undergraduate women's experiences at a small predominantly White private liberal arts college. This comparison is useful to understand the positive or negative qualities within these three departments which can help build a model for other departments to strive for.

(CO-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Characteristics of Women and Men Who Typically Worked Alone vs. Worked with Peers in Introductory Physics Courses

Presenting Author: Apekshya Ghimire, University of Pittsburgh

Meaningful collaboration with peers inside and outside the classroom can be an invaluable tool for helping students learn physics. We investigated the characteristics of women and men who most typically worked alone vs. those who typically worked with their peers in their algebra-based and calculus-based introductory physics courses when they took these courses before and during the COVID-19 pandemic. We will discuss these findings related to students' prior academic preparation, physics grade and self-efficacy as well as their perception of the effectiveness of working with peers on their physics self-efficacy.

Session DA: AI in the Classroom

Location: Harbor Level, Harbor I **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Andrew Gavrin

(DA-01 3:00 PM-3:12 PM) | | Using AI-powered Tools in Physics and Astronomy Courses at UCLA

Presenting Author: Alexander Kusenko, UCLA

I will discuss the use of AI powered tools in our Physics and Astronomy classes at UCLA and the ongoing study of these tools' effectiveness for learning outcomes as well as their use by different student demographics. We have integrated AI tools into the homework platform, where the students receive AI powered hints and practice problems on demand. We have collected the data from hundreds of students using these AI tools, and we have analysed (i) the use of AI tools by the students from different socioeconomic backgrounds, (ii) the effects of AI powered tools on the learning outcomes, (iii) the students satisfaction with AI powered teaching assistance.

(DA-02 3:12 PM-3:24 PM) | | Sensitive Dependence on Initial Conditions, How AI Predictably Fails Unpredictably

Presenting Author: Jedediyah Williams, Belmont High School

There is a remarkably uncritical push for AI in education, with little regard for the substantial body of work demonstrating how and why we should be reasonably skeptical of the utility of technologies attempting to model complex systems. Physics teachers are perhaps uniquely positioned to recognize, understand, and communicate the technical pitfalls of modeling complex systems. Some of those technical pitfalls correspond to ethical pitfalls. AI systems are known to propagate harms in ways as variable as the contexts in which they are applied, often amplifying biases harmful to the historically marginalized. We will discuss some of the critical issues that responsible educators might consider when incorporating or developing AI systems in education, including a review of resources of critical AI work with highlights and lowlights of AI technologies.

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(DA-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Using and Teaching AI in the Physics Classroom

Presenting Author: Gary Garber, St. Mary's High School of Lynn

In this talk I will give an overview of the way I have my students use AI in the classroom. I will present reflection on using the Day of AI Curriculum to teach the 5 Big Ideas, Deep Fakes, and using AI Tools to write portions of lab reports. Some students are able to use the tools effectively but many lack the perserverance, knowledge, and patience to create high quality writing.

Session DB: Highlights of Journals: TPT and Phys Rev-PER II

Location: Harbor Level, Harbor II **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Gary White

(DB-01 3:00 PM-3:24 PM) | | Integrating Arduinos into Introductory Circuit Labs

Presenting Author: Donald Smith, Guilford College

In the last few years, microprocessors have been used in ever-increasing ways to teach introductory physics and engineering. They have been used to support inquiry-based advanced lab sequences, modeling framework labs, and project-based physics labs. It is possible to use them with smartphones as well as Vernier sensors to record and process experimental data. During the pandemic of COVID-19, I took the opportunity to redesign our introductory circuitry lab sequence to build on a foundation of Arduino activities. The versatility and portability of these devices afforded an opportunity to introduce students to concepts of voltage, current, and resistance within an exploratory context. I chose an Arduino board that was specifically designed for education and developed a sequence of six laboratory activities to build the students' understanding and competence step by step. The scaffolded programming tasks, combined with open-ended explorations and encouragement to think about what else the technology could do, fostered creativity, confidence, and self-efficacy. I will present the labs I developed, demonstrate how students engaged with them, and share some of the developments I have built since my published report in The Physics Teacher.

(DB-02 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | What Has Happened in PRSTPER Since it is Launched?

Presenting Author: Xian Wu, University of Connecticut

Additional Author | Rachel Ainsworth, University of Connecticut

Additional Author | Isaac Pena, University of Connecticut

This study reviewed over 800 papers published in Physical Review Special Topic: PER from the inaugural volume in 2005 to the 19th volume in 2023. We categorized all papers based on their research objectives, context, and data. Additionally, quantification was conducted to ascertain the prevalence of specific physics concepts as well as the exploration of various social, technological, pedagogical, and psychological dimensions within the research corpus. The study revealed trends shaping the landscape of physics education research over the past two decades.

Session DC: Effective Practices in Educational Technology: Learning with Interactive Technology

Location: Harbor Level, Harbor III **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Anne Cox

(DC-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | PlayPosit for Interactive Online Physics Lectures

Presenting Author: Kathryn McGill, University of Florida, Department of Physics

I will share my experiences in teaching with PlayPosit for the first time in my Spring 2024 UF Online course, Applied Physics 2, which covered introductory electricity, magnetism, quantum physics, and nuclear physics. My PlayPosit lectures were designed and recorded with the assistance of the instructional design team from the UF Center for Online Innovation and Production, an experience I would like to share in encouraging other physics instructors to work with instructional designers to improve their own courses.

(DC-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | HTML5 Physics Simulations

Presenting Author: Andrew Duffy, Boston University

There is a nice collection of HTML5 physics simulations available, at https://physics.bu.edu/~duffy/sims.html In this talk, I will talk about ways we use these simulations in class, focusing in particular on geometrical optics and the interference and diffraction of light. For hybrid labs on those two topics, we have incorporated simulations so the students see ideal situations, which they can then contrast with what happens in real life. I will also discuss our project of writing worksheets to accompany the simulations. This work is supported by the NSF through grant DUE 2120980.

(DC-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Three MARVLS Augmented Reality Apps for Physics

Presenting Author: Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

Additional Author | Benjamin McColgan, MARVLS, LLC

Additional Author | Natalie Stagnitti, South Colonie School District

Undergraduate students struggle to visualize abstract and 3D concepts in physics and engineering. There is a need for context-specific spatial visualization activities to help students connect abstract physics concepts, 2D representations, and variables in equations to 3D models. Students and instructors can utilize these AR apps in a variety of situations including for use within lectures, problem solving sessions or labs either within in-person or remote instruction. Three MARVLS Apps are presented on Physics I, Physics II, and Plasma Physics concepts and are available on the App Store and the Google Play Store.

Session DD: Innovations in Teaching Beyond Introductory Physics II

Location: Lobby Level - Marina Ballroom II **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Tonya Coffey

(DD-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Transforming a Second Year Physics Course to use Active Learning at a Research Intensive University

Presenting Author: Michelle Tomasik, MIT

Additional Author | Alex J Shvonski, MIT

While many first year physics courses now use active learning, fewer higher level courses have active learning elements at large Research Intensive Universities. The vast majority of our first year students take an introductory physics course designed with active learning elements, but subsequent higher-level physics courses have been lecture-based. It was observed that students transitioning into a sophomore-level class, who previously took an active learning introductory class, subsequently dropped the sophomore-level class at a higher rate compared to students who previously took a lecture-based introductory class. In an attempt to remedy this, more active learning elements and extra background resources have been added to the second year course, and have been maintained amid a change in primary instructor. The path forward to enacting educational change is highly institution-dependent, but there are common elements: support from leadership, capable and willing instructors, and student buy-in. Using this framework, we discuss the changes made and report on students' perceptions and feedback.

(DD-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Bridging the Gap Between Spins and Particles

Presenting Author: Gerardo Giordano, King's College

Additional Author | Artur Tsobanjan, King's College

The "spins-first" approach to introductory quantum mechanics quickly immerses students in some of the most interesting parts of quantum mechanics by beginning with Dirac notation and the experimental results of successive series of Stern-Gerlach spin measurements before progressing to wave functions. Although this approach is great at illustrating the new features of quantum mechanics that have no classical parallel, switching from the discrete nature of spin measurements to continuous measurements of observables like position can be confusing for first time students. In this talk, we present one of the activities that we use in our introductory quantum mechanics course to narrow this separation. By slowly transitioning from inner products involving summations to inner products involving integrals, we offer students a more gradual introduction to wave functions and probability densities.

(DD-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Introducing Rasch Model as an Application of Fermi-Dirac Distribution

Presenting Author: GUOFU MA, The Ohio State University

Additional Author | Lin Ding, The Ohio State University

We propose an innovative strategy for teaching Fermi-Dirac (F-D) distribution, where Rasch model is introduced as a special application of F-D distribution in physics education research . Mathematically, both models share the same form of logistic function. While Fermi-Dirac distribution describes the average number of fermions in a single-particle state given its energy relative to the total chemical potential, Rasch model depicts the probability of a respondent correctly answering a question given his/her ability relative to the item difficulty. The similarity between the two models can offer students a unique opportunity to bridge physics concepts with education research methodologies, thereby fostering a cross-disciplinary understanding. By exploring parallels between the models, students can grasp the fundamentals of educational measurement while deepening their comprehension of Fermi-Dirac distribution. Targeted at STEM education majors, this teaching strategy can be employed to cater to students who are interested in education research and seeking clarity on Rasch modeling.

(DD-04 3:36 PM-3:48 PM) I Contributed Talk (12 Minutes) I Statistical Mechanics as a Case Study for Challenges in Upper-Division Physics Courses

Presenting Author: Ebba Koerfer, Uppsala University

Additional Author | Bor Gregorcic, Uppsala University

There is a need for expanding research on upper-division physics courses, in particular topics such as thermal physics. Our study took a grounded approach to exploring challenges that arose when small student groups engaged in collaborative problem solving in statistical mechanics. The presentation will discuss how students navigated the abstract and subtle concepts of statistical mechanics, and the difficulties they experienced while solving problems. The talk will summarize the categories of student challenges that we have identified in our empirical study, and present some of them through illustrative examples. We will also discuss the educational implications of our findings and the possible connections to other upper-division courses with a similar reliance on abstract physics concepts and demanding mathematics.

Session DE: Learning from the Eclipse III

Location: Lobby Level - Marina Ballroom III **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Ann Schmiedekamp

(DE-01 3:00 PM-3:24 PM) I I Student-Driven Radio Observations of the Sun and the Ionosphere During the 2024 Total Solar Eclipse

Presenting Author: Timothy Dolch, Hillsdale College / Eureka Scientific

Additional Author | Olivia Young, Rochester Institute of Technology, National Radio Astronomy Observatory

Additional Author | Joseph Helmboldt, US Naval Research Laboratory

Additional Author | Michael Lam, SETI Institute

Additional Author | Sofia Valentina Sosa Fiscella, Rochester Institute of Technology

Additional Author | Christopher Mentrek, Geauga Park District

On 8 April 2024, a total solar eclipse will traverse the continental United States. The totality time will be almost twice that of North American solar eclipse of 2017. This rare event provides a unique opportunity to study the response of the ionosphere and to generate radio images of the Sun during the eclipse. We are constructing a Deployable Low-Band Ionosphere and Transient Experiment (DLITE) station within the path of totality. DLITE is a four-element interferometric radio telescope utilizing Long Wavelength Array antennas. The antennas are separated by 300m, allowing us to distinguish bright cosmic radio sources uniquely situated in the line of the eclipse's path of totality. Our station will observe from the grounds of Observatory Park in Montville, OH. We will: (i) study the impact of the reduced solar UV radiation on total electron content gradients, (ii) probe turbulent irregularities in the ionosphere, and (iii) produce radio images of the Sun. Beyond the eclipse, the DLITE station will continue monitoring the ionosphere and will search for astrophysical transient sources. The construction and operation of DLITE is student-driven, and we will collaborate to maximize outreach before, during, and after the eclipse.

(DE-02 3:24 PM-3:48 PM) I I The Dynamic Eclipse Brodcast Initiative

Presenting Author: Robert Baer, Southern Illinois University Carbondale

Additional Author | Matt Penn, Southern Illinois University Carbondale

Additional Author | Corinne Brevik, Southern Illinois University Carbondale

Additional Author | Harvey Henson, Southern Illinois University Carbondale

Additional Author | Christopher Manrell, Southern Illinois University Carbondale

Additional Author | Heidi Bjerke, University of Illinois Champaign Urbana

The DEB Initiative is collaborative citizen science project that establishes a North American solar observation telescope network with the primary goal of creating coronal data set along the 2024 TSE eclipse path from Mexico to Canada. DEB currently has 82 observation teams training to observe the 2024 TSE that include 40 teams funded by NASA SMD and 20 girl group specific teams funded by NSF through a partnership with Einstein's Incredible Universe, a large screen format documentary. DEB teams currently stream solar observation data to debra.physics.siu.edu and will continue to throughout the project. The public may use the site at any time to see observation, however it is mostly intended for public sharing of data during large events such as the October 14, 2023 ASE and the April 8, 2024 TSE as well as our own internal team's use at any time. The DEB telescope network is capturing solar data in the hopes of getting high cadence imagery of solar flares, and capturing coronal data during the 2024 TSE to measure the acceleration of the solar corona to approximately 3X solar radii. Preliminary results from our April 8, 2024 observations will be discussed.

Session DF: Teaching Quantum Mechanics to Promote Workforce Development II

Location: Lobby Level - Marina Ballroom IV **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** : James Freericks

(DF-01 3:00 PM-3:24 PM) | | A Student-centered, Spins-first Approach to Undergraduate Quantum Mechanics Instruction

Presenting Author: Steven Pollock, University of Colorado, Boulder

Additional Author | Gina Passante, California State, Fullerton

Additional Author | Bethany Wilcox, University of Colorado, Boulder

Additional Author | Homeyra Sadaghiani, California State Polytechnic University Pomona

Undergraduate quantum mechanics instruction with an eye to workforce development likely includes fundamental conceptual and traditional analytic tools of quantum mechanics, but may also emphasize contemporary aspects including a spins-first approach, elements of single particle measurements, and aspects of quantum information. Faculty teaching quantum mechanics may seek research-based pedagogical elements to support interactive engagement, and formative assessment. In this talk we share a set of modular, freely available teaching materials to help instructors with these goals. They were built based on research into student learning, and have been field-tested in a variety of classes. They are not prescriptive in terms of teaching methods, but include conceptual questions for use in class and homeworks, group activities, faculty guides and notes, and course-level conceptual assessments, including a new instrument focused specifically on Quantum information. Our online tutorials allow for many of the benefits of tutorials when class time is limited or students' needs are varied. They provide dynamic feedback to students and can be assigned for out-of-class use either as individuals or for groups. All materials are available at https://www.physport.org/curricula/aceqis/ or …/aceqm/

(DF-02 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Transitioning Paper Tutorials to an Online Platform with Interactive Feedback

Presenting Author: Jonan-Rohi Plueger, University of Colorado, Boulder

Additional Author | Steven J Pollock, University of Colorado, Boulder

Additional Author | Gina Passante, California State University - Fullerton

Additional Author | Bethany R Wilcox, University of Colorado, Boulder

The active-learning opportunities afforded by physics tutorials have been shown to effectively improve students' conceptual understanding in topics both from introductory physics and upper-division physics. Many professors, however, find it hard to justify using precious class time on a tutorial, or may not have the resources to run one. We have been developing a way to transfer paper tutorials online with interactive feedback/guidance messages, and in this talk I will discuss how we did this for quantum computing-related tutorials, how others might do the same, and what are the pros and cons of online tutorials.

(DF-03 3:36 PM-3:48 PM) | Contributed Talk (12 Minutes) | What Students' Language Reveals About Conceptual Understanding of Quantum Measurement

Presenting Author: Amy Lytle, Franklin & Marshall College

Additional Author | Ethan Senatore, Franklin & Marshall College

Conceptual metaphors are useful for understanding abstract or complex ideas in terms of concrete ideas (e.g. Time as Money: "I spent time writing this abstract."). How students talk about the highly abstract ideas in quantum mechanics can both shape and reveal aspects of their conceptual understanding. We examine the conceptual metaphors and ontological categorization undergraduate students use in their language about quantum ideas in a spins-first curriculum, particularly quantum measurement or observation. We find that students use and switch between multiple conceptual domains, using metaphors like Measurement as Seeing, Measurement as Receiving, Measurement as Affecting. Identifying these metaphors and their limitations can help us assess student understanding, as well as speak about quantum measurement in productive ways for learning.

Session DG: Effective Practices for Developing Scientific Reasoning and Decision-Making Abilities III

Location: Harbor Level, Lewis **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Jayson Nissen

(DG-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Inertia in Action: Practical Lessons on Forces and Motion

Presenting Author: Dylan Fedell, Palisades High School

In this presentation, I will share a unique series of lessons on inertia with pedagogical insights, resources, and examples of student work. As a high school physics teacher, I've developed a unit in my Physics I course that combines the principles of forces and motion with the context of our student athletes' safety. Centered around the debatable question, "Should our student-athletes wear helmets?", this unit culminates with the concept of inertia and its application by predicting the motion of a human brain during a collision. The unit, framed around an anchoring phenomenon of two soccer players' heads colliding, is designed to engage students who are often student-athletes in scientific argumentation answering the question, "In which direction will the brain move in a collision?"

(DG-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Pre-service Elementary Teachers' Understandings of Scientific Inquiry

Presenting Author: Maddie Wutke, Drury University

Co-presenting Author | Ying Cao, Drury University

Additional Author | Edward A. Williamson, Drury University

In this study we adopted a mixed method approach to research pre-service elementary teachers' understanding of scientific inquiry. A survey was developed referencing the National Science Education Standards for Inquiry and previous work in the area. Three groups of elementary education students participated in the survey in two academic semesters. A semi-structured interview was conducted with a subset of the participants. The Likert-scale survey results were analyzed statistically. Open ended survey responses and interview transcripts were coded qualitatively. The ongoing goal is to compare results with those from an earlier study at the beginning of the 21st century. We hope to capture some evolutionary patterns in pre-service teachers' understandings of scientific inquiry and generate implications to elementary science education, particularly concerning the evident shift away from an emphasis on usage of the term "scientific inquiry" in the Next Generation Science Standards.

(DG-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | 9 Solar System Myths you Might Actually Believe In

Presenting Author: James Lincoln, SCAAPT

The most concerning type of myths are the ones you might be teaching to your students! In the process of learning about the solar system, we are all subject to forming our own (often incorrect) opinions because there is little opportunity for direct observation. To questions that no one is around to answer. Some of these myths are well-known and well-published, others are subtle, and you may not have even realized that you believe it them. Together we will find the answers and you can suggest more myths for us to debunk.

(DG-04 3:36 PM-3:48 PM) | Contributed Talk (12 Minutes) | Using Pop Culture to Get Students Excited About Physics: Analyzing Portrayals of Kinematics and Dynamics in Science-accurate Shows Like The Expanse

Presenting Author: Sheehan Ahmed, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

Additional Author | Joshua Rutberg, Rutgers University - Newark

Analyzing physics in pop culture, as presented in television and cinema, is one way to get students excited about science and science fiction. In this talk we present the physics used in TV shows including The Expanse and share classroom activities based on these portrayals. Students analyze a scene and use ideas and tools previously developed through inquiry based activities to critique scenarios. We also identify and critique notions of gender, identity, and power depicted in this series. Comparing more accurate to less accurate physics portrayals can be a useful exercise for students to utilize and improve their analytical and critical thinking skills gained in introductory physics courses. We will show specific examples of activities and application problems made out of these portrayals that can be used as tools by educators in their introductory courses.

Session DH: PER: Learning Through Collaborative Experiences

Location: Mezzanine Level - Douglass **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Victoria Borish

(DH-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | An Investigation of Socio-metacognition as Groups Discuss Fictionalized Student Dialogues: Part 1 (Overview)

Presenting Author: Andrew Boudreaux, Western Washington University

Additional Author | Thanh Lê, Western Washington University

Additional Author | Jayson Nissen, Nissen Education Research and Design

Additional Author | Carolina Alvarado, California State University - Chico

Many physics curricula use fictionalized student dialogues (FSDs) to present contrasting lines of reasoning about concepts and phenomena. These lines of reasoning are often drawn from research on student understanding. During instruction, students are expected to collaboratively discuss and assess the contrasting lines of reasoning, identifying normative reasoning as well as flawed arguments. This can lead to confusion as the group weighs competing ideas. Successful resolution of such confusion relies on the group's ability to regulate their collective thinking. At Western Washington University and Cal State Chico, we are investigating how collaborative student groups engage with FSDs. We have collected classroom video in a course for preservice teachers that uses the NextGen PET curriculum, and are analyzing these data with a socio-metacognitive framework adapted from Borge and colleagues. This framework involves specific communication patterns associated with collective sense making, including developing joint understanding, joint idea building, exploring alternative perspectives, and proposing high quality claims. This talk will describe the communication patterns and share short examples from the data corpus of groups that display collaborative competence with selected patterns.
Research supported by NSF DUE-2021547 and DUE-2021307

(DH-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | An Investigation of Socio-metacognition as Groups Discuss Fictionalized Student Dialogues: Part 2 (Analysis)

Presenting Author: Thanh Lê, Western Washington University

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Jayson M Nissen, Nissen Education Research and Design

Additional Author | Carolina Alvarado, California State University, Chico

Collaborative learning is increasingly common in physics education. A challenging aspect of collaboration for groups is how to manage and resolve confusion. During these moments of confusion, socio-metacognition is especially important for successful collaboration. In this study, we focus on student small group discussions as they engage with fictionalized student dialogues (FSDs). In an FSD, two or more fictitious students present contrasting perspectives on a physical phenomenon, which can trigger confusion. We collected classroom video for 25 groups in physics courses for pre-service K-8 teachers using Next-Gen Physics and Everyday Thinking. We applied the socio-metacognitive framework of Borges et al. to student discussions of the FSDs. In this talk, we will describe student socio-metacognitive patterns for four different FSDs, focusing on the extent to which students discuss alternative perspectives and propose high quality claims. Understanding how students engage in socio-metacognition during moments of confusion is important to support productive collaboration and learning.
Research supported by NSF DUE-2021547 and DUE-2021307.

(DH-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | How Collaborative Experiences Are Entangled with Student Beliefs: Initial Findings from a Design-based Research Project

Presenting Author: Eric Kuo, University of Illinois Urbana-Champaign

Additional Author | Sarat Lewsirirat, University of Illinois Urbana-Champaign

Additional Author | Ellen Ouellette, University of Illinois Urbana-Champaign

Additional Author | Vidushi Adlakha, Indiana University–Purdue University Indianapolis

Additional Author | Morten Lundsgaard, University of Illinois Urbana-Champaign

Additional Author | Christina Krist, University of Illinois Urbana-Champaign

This study investigates how collaborative experiences in an introductory physics course are entangled with students' learning-relevant beliefs – such as those related to epistemology, growth mindset, and sense of belonging. As a piece of a larger design-based research project investigating structural messaging in a focal physics course, introductory physics students were interviewed on their perceptions of their course experiences, including collaborative experiences. Using excerpts from these interviews, we will illustrate initial findings on how students relate collaborative experiences to their belief development and, reciprocally, how students' beliefs impact their construal of collaborative experiences. We use these qualitative data to illustrate how this approach can (i) provide a complementary perspective to a growing body of quantitative survey research on student beliefs and (ii) inform the development of course design principles through empirical data on student experiences and beliefs.

(DH-04 3:36 PM-3:48 PM) | Contributed Talk (12 Minutes) | Gesturing Together in Collaborative Problem Solving in Physics: Co-constructing Explanations

Presenting Author: Benedikt Harrer, University at Buffalo (SUNY)

Additional Author | Virginia J. Flood, University at Buffalo (SUNY)

Additional Author | Emma T. Booth, University at Buffalo (SUNY)

In this study, we demonstrate how students repeat each other's representational gestures to tie together collaboratively constructed physics explanations, when different elements of an explanation are contributed by two or more students. This practice has previously been observed in collaborative diagnostic work in medical training settings. We draw on Goodwin's concept of Intertwined Actors to understand how multiple participants co-author single actions and utterances through embodied interaction. Data for this microethnographic study come from video recordings of undergraduate students working together in a highly interactive classroom using the CLASP curriculum to model the energy dynamics of various scenarios. Our goal is to better understand the ways students achieve close forms of coordination in group work and the different types of co-construction that arise in these settings. We discuss implications for teaching and learning. This study is part of the NSF-funded DiGEST Physics project.

This material is based upon work supported by the National Science Foundation under Grant No. 2201821.

Session DI: Dual Enrollment Physics: Conversations with TYC & K-12 Educators

Location: Grand Ballroom D **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Danielle Bugge

In this session, participants will engage in conversation on teaching dual enrollment physics. First, participants will learn about the benefits, successes, and challenges of dual enrollment programs from a panel of college and high school teachers currently instructing with this model. The second half of the session will be dedicated to conversations surrounding strategies of implementing and/or maintaining successful dual enrollment programs.

Panelists:

Thomas Herring, Western Nevada College

Brittney VornDick, Durham Technical Community College

Kathy Willard, Monessen City School District, University of Pittsburgh at Greensburg

Session DJ: Strengthening Your Physics Programs: Working with Counselors

Location: Grand Ballroom C **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Bree Barnett Dreyfuss

(DJ-01 3:00 PM-3:24 PM) | Working with Counselors to Strengthen Your Physics Programs

Presenting Author: Bree Barnett Dreyfuss, Amador Valley High School

High school counselors, like the rest of the general population may have had the same mixed experiences with high school physics classes. Perhaps due to an unconscious bias, they may not encourage eligible students to enroll in your physics programs, or to continue into advanced physics courses. Building on the STEP UP program's information for counselors to encourage more women to take high school physics, we will present information to share with your counselors and students' families during scheduling. This talk is to be followed with a topical discussion time to work with others to determine actionable next steps and builds on the Winter 2024 talk on inclusive actions

(DJ-02 3:24 PM-3:48 PM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Discussion: Strengthening Your Physics Programs: Making Counselors & Families Allies

Presenting Author: Kori Bowns-Kamphuis, Lindblom Math and Science Academy

Join this topical discussion to discuss with other high school teachers how to strengthen your physics programs by partnering with your guidance counselors. Following a talk about how to present counselors and families with statistics on the gender and race/ethnicity gap in physics, participants can discuss in small groups what actionable steps they plan to make. This work is supported by the National Science Foundation under Grant Nos. 2300607,1720810, 1720869, 1720917, and 1721021 and the Gordon & Betty Moore Foundation DOI: doi.org/10.37807/GBMF11451

Session DK: PER: DEI

Location: Concourse Level - Commonwealth B **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Clausell Mathis

(DK-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Developing a Conceptual Framework for Narrative Physics Identity

Presenting Author: Junhee Kim, Daegu University

Additional Author | Sungmin Im, Daegu University

The status approach, widely adopted in the current methodology for studying physics identity, focuses on measuring the present with an expectation that it will extend into the future. In contrast, the narrative approach centers on reconstructing past experiences to better understand the present and anticipate the future. While the status approach has been criticized for failing to capture the socio-cultural background of individuals, it might be the narrative approach that can be the key to this point. This paper aims to capture the characteristics of individuals' narrative physics identity by employing a narrative approach. Subsequently, it also aims to develop a conceptual framework for narrative physics identity. The research was conducted with three college students aspiring to pursue careers in the field of physics. We interviewed these students and analyzed the data using narrative inquiry. In this paper, we present a conceptual framework for narrative physics identity consisting of three dimensions: Experience, Cognition, and Commitment. Experience is composed of two factors: personal experience and socio-cultural experience. Cognition represents the current science identity. Finally, Commitment is composed of two factors: personal and socio-cultural

(DK-02 3:12 PM-3:24 PM) I Contributed Talk (12 Minutes) I Examining Communal Classroom Cultures: Comparing Physics Teachers' and Students' Perceptions

Presenting Author: Chelsea Mateu, Florida International University

Co-presenting Author | Zahra Hazari, Florida International University

Co-presenting Author | Pooneh Sabouri, Florida International University

Additional Author | Claudia Frachhiolla, American Physical Society

Communal Classroom Cultures (CCC) are spaces that fully engage students in learning physics both cognitively and affectively through a shared sense of community. Prior research has found that classes that have communal cultures are more likely to engage and inspire student persistence, particularly for students with marginalized identities. We developed a set of items that measure aspects of CCC for physics teachers and students. This talk will present the theoretical aspects of CCC, provide reliability and validity results for the CCC measures, and compare physics teachers' and students' responses to the CCC measures. The latter findings provide insight into where disconnects may exist in the way that students and teachers perceive the classroom environment. Understanding these disconnects is important for allowing teachers to create learning environments that are meaningful for all students as a community and not just as isolated individuals.
This work is supported by the National Science Foundation under Grant No. 2300607,1720810, 1720869, 1720917, and 1721021 and Moore and Betty Foundation DOI: doi.org/10.37807/GBMF11451

(DK-03 3:24 PM-3:36 PM) I Contributed Talk (12 Minutes) I The Landscape of Physics Education: Contextual Tours with Historical Experiments, Story-Telling, Feminism and Indigenous Experience

Presenting Author: Elizabeth Cavicchi, Edgerton Center, MIT

Additional Author | Riley Moeykens, MIT

Additional Author | HIllary Diane Andales, University of Chicago

We reviewed new methodologies in physics education research (PER), that incorporate history, philosophy and sociology, in contributing to The International Handbook of Physics Education Research, AIP, 2023. To represent these new PER methodologies, we present the metaphorical Landscape of Physics Education. In this landscape, decontextualization is represented by elevation, with greatest decontextualization at mountain peaks. Our metaphor uses water to represent educators' contextualizing efforts. At lowest elevations, physics is fully contextualized: teachers prioritize content and context; students' voices and identities are celebrated. Educators and students throughout this landscape are informed and inspired by: constructivism; nature of science (NOS); student voice; and gradings' adverse impacts. As our survey demonstrates, there are many methods of introducing water's contextualizing action. Innumerable tours are possible. We describe three tours: Historical Experiments and Instruments; Contextualization through Narratives, and Feminist and Indigenous Experience. Historical experiments and instruments offer educational methods for learners to experience materials, phenomena, uncertainty and observation. Stories engage learners through practical, theoretical, social, and affective contexts. Feminist and indigenous practices open to relational dialogue with others, history and nature. We encourage physics teachers and students: re-view your landscape, try new routes, and reshape the landscape while being open to being reshaped by it.

(DK-04 3:36 PM-3:48 PM) I Contributed Talk (12 Minutes) I Bridging the Gap: Data-Driven Insights for Equitable Physics Instruction

Presenting Author: Chloe Elise Hennessy, South Seattle College

Additional Author | Elizabeth A. Schoene, South Seattle College

Additional Author | Abigail R. Daane, South Seattle College

Within STEM, physics ranks among the least aligned with the US population regarding racial and gender representation. This not only has the potential to hinder new discoveries and innovations, it also highlights a lack of equitable opportunities for individuals. In an effort to identify ways in which teaching practices may contribute to this problem, our research explores correlations between active learning strategies and growth in students' conceptual understanding. The data analyzed are from a pre/post survey in a two-year college calculus-based introductory university physics class with a primarily Vietnamese, Black, and white population. We present topics including force and free-fall that show either substantial or limited improvement in student learning gains. We compare data across several demographics, and relate corresponding learning activities. We provide recommendations to improve both learning outcomes and instructional methods, with the aim of increasing opportunities for all identities to complete degrees and pursue career goals.

(DK-05 3:48 PM-4:00 PM) I Contributed Talk (12 Minutes) I Barriers to STEM: Exploring Physics Students' Path to the Physics Major

Presenting Author: Anika Jones, Georgia Institute of Technology

Additional Author | Emily Alicea-Munoz, Georgia Institute of Technology

Students of different ethnicities and socioeconomic backgrounds have different life experiences that can result in barriers to entry into STEM fields. Physics, in particular, has low gender and racial diversity, and the percentage of underrepresented minorities in physics diminishes the higher one goes in the academic ladder. In this study we gathered qualitative data that could be used to guide the development of interventions to lower barriers and achieve higher diversity in physics. We first interviewed physics undergraduate and graduate students to determine what barriers, if any, they encountered on their academic paths and identify potential correlations between barriers and gender, ethnicity, and socioeconomic status. We also interviewed a small number of teachers and administrators at nearby K-12 schools to explore what resources they have and what limitations they currently encounter in developing and improving science and math curricula that service underrepresented students. In this talk, we present the results of our qualitative analysis and discuss implications for the future.

Session DL: Thriving and Rising Physics Teachers Preparation Programs: A Roundtable Discussion with Representatives from High-Production Teacher Preparation Programs

Location: Grand Ballroom E **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Spencer Perry

(DL-01 3:00 PM - 3:48 PM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Thriving and Rising Physics Teacher Preparation Programs: A Roundtable with Representatives from High-Production Teacher Preparation Programs

Presenting Author: Spencer Perry, Indiana University Bloomington

Additional Author | Duane Merrell, Brigham Young University

Additional Author | Robert Goodman, New Jersey Center for Teaching and Learning

Additional Author | Robert Zisk, Rutgers University

Additional Author | Keith Sheppard, Stony Brook University

Additional Author | Eleanor Close, Texas State University

PhysTEC recognizes teacher preparation programs that produce an exceptionally high number of physics teachers with the annual PhysTEC "5+ Club" award. Eligibility for this award includes a requirement to graduate five or more physics teachers in an academic year—well above the national average. This roundtable discussion will bring representatives from some of the "thriving programs" (programs that have an established history of winning the 5+ Club award) as well as some other "rising programs" (programs that have been recent and regular winners of the 5+ Club award). The discussion will focus on what happens at each of the institutions represented and consider implications for transferring those practices to new contexts. The discussion will also include opportunities for audience questions.

Session DN: PER: Access and Inclusion – Creating Pathways

Location: Lobby Level, Stone **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Jim Kernohan

(DN-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Building Pathways for Black Students in Physics at Rutgers-Newark

Presenting Author: Diane Jammula, Rutgers, Newark

Additional Author | Sheehan Ahmed, Rutgers-Newark

Additional Author | Joshua Rutberg, Rutgers-Newark

The TEAM UP Report, released by AIP in 2020, challenged physics departments to double the number of Black physics majors by 2030. We present how the Rutgers-Newark (RU-N) Physics Department is heeding this call to action by leveraging programs already successful at RU-N and implementing new strategies that align with findings from the TEAM-UP report. RU-N is a Hispanic Serving Institution in the heart of Newark, a predominantly Black city. The RU-N physics department has undergone significant changes in the last 5 years with active learning introductory courses; a Learning Assistant program; redesigned undergraduate and graduate programs; and new faculty. The goal of this initiative is to build pathways from high school and community college through the physics major to career or graduate school for Black students. Project pieces include: i) physics department training to support cultural change; ii) building relationships with local predominantly Black high schools and community colleges; iii) frequent holistic advising; and iv) industry partnerships. We present quantitative indicators and qualitative feedback from students and stakeholders. This is a work in progress; we hope to spark conversation.

(DN-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Exploring the Historic Origin of Cultural Gatekeeping in Physics Education

Presenting Author: Daniel Sharkey, University of Central Florida

Additional Author | Jacquelyn J Chini, University of Central Florida

Culture in departments is rooted in history; by analyzing the historical culture of physics departments, we may come to a new understanding of attitudes, unspoken assumptions, and ideas that permeate contemporary culture. Here, we examine the evolution of the idea that physics education should serve as a filter, a practice commonly called gatekeeping. Physics graduate education saw great reform throughout the early and mid-20th century, with many calls to organize and standardize the disordered, haphazard system that was present. Concerns were voiced about the education process and the quality of the students who were granted degrees. These calls to reform resulted in a variety of changes that were designed around the needs of the student body at the time. In the present, our field is more diverse than ever before, and our current standards and expectations fail to support these learners. However, this failure is often seen as the student's failure rather than the system design's failure. This project analyzes gatekeeping through 20th-century calls for reform, argues that modern policies that disadvantage minoritized students are kept around due to a perceived need to gatekeep the subject, and advocates for more consideration of a department-deficit model to explain inequities.

(DN-03 3:36 PM-3:48 PM) | Contributed Talk (12 Minutes) | Leveraging Learning Assistants (LAs) as Instructional Leaders and Change Agents

Presenting Author: Mel Sabella, Chicago State University

Additional Author | Trinity Thomas, Chicago State University

Additional Author | Vivian Cox, Chicago State University

Additional Author | Jacquelyn Benchik-Osborne, Chicago State University

Additional Author | Andrea G. Van Duzor, Chicago State University

The Learning Assistant (LA) Model leverages undergraduate students (LAs) as facilitators of learning in active engagement classes. Often, LA roles go beyond the classroom as LAs are involved in instructional changes across the institution and in the broader learning community. We suggest a framework for identifying LA leadership and provide examples of leadership across multiple colleges at Chicago State University and across the Illinois Louis Stokes Alliance for Minority Participation (I-LSAMP), with a specific focus on LA roles in the assessment and evaluation of teaching and learning as well as their role in supporting effective teaching frameworks.

Funded by the Department of Education (CSER, RECESS), the National Science Foundation DUE#1911341, and the CSU Center for Teaching and Research Excellence.

(DN-04 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Physics Education for Social Restoration: A Colombian Case Study

Presenting Author: L. Catalina Arboleda, University of Colorado Boulder and Institución Universitaria Digital de Antioquia

Additional Author | Valerie K. Otero, University of Colorado Boulder

Colombian society faces a historical political challenge to implement the 2026 peace accord, which ended 60 years of armed conflict. Public institutions were called to contribute to social restoration by making efforts to create education opportunities for historically marginalized communities, often isolated due to armed conflict and state abandonment. Virtual classes emerged as a way to expand educational access for these communities. Institutions with virtual capabilities are creating physics classrooms as diverse spaces not only for physics learning but to promote the restoration of the social tissue for vulnerable populations, including victims and perpetrators. We did a descriptive study in a Colombian' online introductory physics class implementing culturally relevant elements of PEER physics curricula combined with PhET Simulations. By analyzing students' reflections and feelings about the course, we provide preliminary results that shed light on how physics can serve as a context for social restoration.

Session DO: Meeting Students Where They Are I

Location: Lobby Level - Otis **Time:** 3–4 p.m. **Date:** Monday, July 8, 2024 **Moderator:** Raeghan Graessle

(DO-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Math Tools Course for Incoming BSU Students

Presenting Author: Jamie Kern, Bridgewater State University

Co-presenting Author | Jeffrey J Williams, Bridgewater State University

Additional Author | Allison Daubert, Bridgewater State University

The Physics Department at Bridgewater State University has introduced a new course, PHYS 153 Math Tools for Physics and Engineering for students who do not place into calculus and will not be able to take introductory physics in their first year. This prevents them from making connections to the physics department (faculty, students, and clubs) during their first year. Successful completion of the course allows students to take introductory physics in the spring semester of their first year regardless of math placement. Key components of the class are topics derived from math skills needed for success in introductory physics. Department faculty and department student clubs give guest lectures in the course so that new students learn about opportunities to get involved in physics.

(DO-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Rethinking Math Prerequisites for Introductory Physics Majors

Presenting Author: AJ Richards, The College of New Jersey

Additional Author | Angela M Capece, The College of New Jersey

We implemented a curriculum change at our institution, in which we enroll in our calculus-based Physics I course the first-year physics majors who placed into the pre-calculus level, in order to improve their retention and persistence in the major. Prior to the intervention, around 10% of non-calculus-ready students were retained within the major. Following the intervention, more than half of the students have either successfully graduated with a physics degree from our institution or are currently progressing through the major. This intervention can help address demographic disparities in physics education, since women, students from ethnic minorities, and first-generation students are overrepresented in the non-calculus-ready group. In this paper we present the outcomes of the intervention, describe the strategies employed to accommodate and support non-calculus-ready students, and hopefully offer a blueprint for departments seeking to create more inclusive learning environments that lead to better retention.

(DO-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Afterwaves of COVID in Teaching Introductory Physics

Presenting Author: Michelle Chen, Point Loma Nazarene University

Is the Physics education really back to normal after the COVID pandemic? In this talk I will share my first-hand observations in teaching introductory physics prior- and post-COVID. Academically, the majority of freshman in 2023 – 2024 received online instructions for at least two to three years of their high school education. This resulted in significant holes in crucial basic math knowledge that hinder students' conceptual understanding and problem-solving skills in physics. Socially, the absence of in-person interactions with instructors and peers impacted students' communication skills and the effectiveness to work in groups. I will discuss novel multi-faceted approaches to develop a comprehensive teaching curriculum tailored to the post-COVID freshmen to effectively enhance student engagement and learning in introductory physics courses.

(DO-04 3:36 PM-3:48 PM) | Contributed Talk (12 Minutes) | Open Educational Resources for An Introductory Calculus-Based Physics Course

Presenting Author: Dawson Nodurft, Texas A&M University

Additional Author | Tatiana Erukhimova, Texas A&M University

Additional Author | William Bassichis, Texas A&M University

Additional Author | Rainer Fries, Texas A&M University

Additional Author | Jeremy Holt, Texas A&M University

Introductory physics courses are gateway courses and can determine whether students continue in their majors. Increasing college costs can make it hard to purchase required course materials for introductory physics courses. Large course enrollments can present barriers, keeping students from engaging with the class and its instructor. Ever-increasing college costs can force students to make difficult decisions on whether to purchase required course materials, such as current editions of textbooks. To alleviate grading burdens for faculty, many required textbooks provide online homework platforms. Access to these platforms increases student costs, and they cannot be accessed unless purchasing a current edition of the course textbook. Limited department resources can make it difficult for faculty to bring in intellectually stimulating experiment demonstrations that can illuminate physical laws in a hands-on way. As part of addressing concerns, Open Educational Resources were developed for calculus-based introductory mechancis course, Newtonian Mechanics. The resources developed include: textbook independent problem sets with solutions, concept review and problem-solving videos, and filmed demonstration experiments. We will discuss the development of these materials and share the impacts we have seen so far in our classrooms.

Astro Posters II

(MON-POS-C-304) | Poster Presentation Traditional | Evaluation of Long Use of Computational Exercises in Teaching a General Astronomy Course

Presenting Author: Raymond Zich, Illinois State University

This study investigated the effectiveness of incorporating computational exercises as an instructional intervention in a general education astronomy course. Results from two control and seven treatment semesters will be presented. Fifteen spreadsheet-based computational exercises were designed and integrated into a single semester general astronomy course taught with an active learning curriculum. The goals in adding the exercises were to deepen conceptual understanding, strengthen the connection between mathematics and concepts, and explore prediction in science. Computation has been shown to be an effective tool for improving student conceptual understanding and deepening understanding of mathematical expressions. The long-term evaluation of the effects of these instructional interventions increased the rigor accuracy precision of the conclusions, as many new curricula only report a semester or two of results before widespread introduction occurs. Student performance pre to post was measured with the Test of Astronomy Standards (TOAST) and the Lunar Phases Concept Inventory (LPCI). Survey data was collected to investigate student attitudes towards computational exercises and general perceptions of the course. Assessment revealed TOAST correctness gains of up to 20%, LPCI correctness gains of up to 29%, and overall positive attitudes towards the computational activities.

(MON-POS-C-306) | Poster Presentation Traditional | Transforming Astronomy Courses with Exoplanets and Search for Life in the Universe

Presenting Author: Tatiana Krivosheev, Clayton State University

Additional Author | Dmitriy Beznosko, Clayton State University

Additional Author | Alexander Iakovlev, Woodward Academy

The science education in universities has several deferring moments for the general student population outside of the Physics/Astronomy fields or STEM in general. A large contribution to that comes from the high cost of the textbooks that is typical for the introductory physics and astronomy courses. Another is the lack of supporting class materials, such as audio-video materials and support tools for activities. This talk will cover the class transformation activities under the ALG grant to adopt the free textbooks from OpenStax for the intro Physics 1-2 and, and to create the supporting materials such as presentations, tests, audio-video materials and in-browser run online tools for the class activities as applicable to the courses listed above. These new materials also include the most recent materials on the extra-solar planet discovery methods and tools, as well as a discussion on the alien life possibility, chemistry of the alien worlds and the habitable zone possibilities around stars of different spectral classes. Adaptations to online or hybrid teaching style will be also noted, and students' survey results will be included as well.

(MON-POS-C-308) | Poster Presentation Traditional | Implementation of Asynchronous, Online Learning for a Fundamentals of Radio Astronomy Course

Presenting Author: Kyle Wipfli, Texas Tech University

Additional Author | Alessandra Corsi, Texas Tech University

As radio astronomy has led to revelations about supernova, astrophysical jets, and exoplanets (Corsi et al., 2014; Anglada et al., 2018; Lynch et al., 2018), it has become more and more necessary to focus on the complicated techniques to gather radio data over other types of data. At Texas Tech University, we have an introduction to radio astronomy course that provides a unique experience to our students to learn these high level techniques through active learning materials. Active learning materials have been shown to improve students' learning outcomes (Aji & Khan, 2019). In collaboration with the NRAO (National Radio Astronomy Observatories), we are designing an asynchronous, online course designed to teach students the fundamentals of radio astronomy. This poster will detail the different sections of the course and how we are using online implementation to increase student engagement.

(MON-POS-C-310) | Poster Presentation Traditional | The Educational Impact of a NASA Moon Tree for Texas A&M University

Presenting Author: Allison McGraw, ammcgraw@tamu.edu

Additional Author | Chloe Ebeling, Texas A&M University

The Physics & Astronomy Department at Texas A&M University has been honored to steward a NASA Moon Tree. This young sweetgum seedling was flown in orbit around the Moon on the Artemis I mission for four weeks in the fall of 2022. This NASA project, a follow-up to the Apollo 14 mission, will visually showcase the return of humans to the Moon. It will also provide the Physics Lab Center with an engaging piece for a large astronomy-themed demonstration for university students and the public. The Moon Tree will be planted at the Mitchell Physics Building and will include visual information to engage viewers with the NASA Artemis program. This display will explain the physical components of the Artemis I flight and orbital path, delta-v, water conservation and filtration on the Moon, and the physics of lunar soils. The Moon Tree will serve as an inspirational educational tool for generations to come.

(MON-POS-C-312) | Poster Presentation Traditional | Galaxy Crash - Student experiments with colliding galaxies

Presenting Author: Steve Cederbloom, University of Mount Union

Galaxy Crash is a VPython program to model galaxy collisions. Students can use it to study how galaxies collide and merge gravitationally, and investigate how the effects of the collision depend on various properties of the galaxies.

(MON-POS-G-602) | Poster Presentation Traditional | Particles Fresh from the Lab in the Astronomy and Modern Physics Courses

Presenting Author: Tatiana Krivosheev, Clayton State University

Additional Author | Dmitriy Beznosko, Clayton State University

For thousands of years, humanity has used only one small window to look at the universe – the window of visible light. Starting with 20th century, the technology has expanded that window into the UV, IR, microwave, radio, X-ray and even gamma-ray range. However, this was all still electro-magnetic radiation. Only two other windows into the universe exist at this time – the gravitational waves and the cosmic rays. The gravitational waves fully belong to the 21st century and are still not a wide-spread knowledge. At the same time, high energy physics has been around for almost a century, thus providing the information and including the topics on high energy physics and/or cosmic rays and how they expand our understanding of the Universe and the conditions right after the Big Bang have become important. The presentation will show how the direct collaboration with the Horizon-T cosmic rays observatory has proven to be very useful in this integration of the latest development in the ultra-high energy cosmic rays field into the curriculum.

(MON-POS-G-604) | Poster Presentation Traditional | Kinetic Energy in Galilean and Special Relativity – A Unified Spacetime Interpretation

Presenting Author: Roberto Salgado, St Catherine University

Relativistic kinetic energy is expressed in a quadratic form that clarifies the relationship between relativistic and non-relativistic kinetic energy. This leads to a unified spacetime-trigonometric interpretation of kinetic energy in terms of the square-magnitude of the “change in the momentum 4-vector (the 4-momentum-gain) from rest” in special relativity and in its analogous formulation in Galilean relativity. We will make use of the hyperbolic-analogues of two now rarely used trigonometric functions—the versed-sine and the chord functions. We relate this to the Work-Energy theorem. Our goal is not to just obtain formulas for kinetic energy, but to give their geometric interpretations on the worldline of a uniformly-accelerated particle in spacetime and on the mass-shell of a particle in an energy-momentum diagram.

*Aspects of Spacetime Trigonometry can be found at http://www.aapt.org/doorway/Posters/SalgadoPoster/SalgadoPoster.htm

(MON-POS-G-606) | Poster Presentation Traditional | Teaching Physics with Bivectors: A Better Language for Rotations and Magnetism

Presenting Author: Steuard Jensen, Alma College

Physicists have traditionally modeled angular momentum and magnetism (and more) using the vector cross product. But students struggle with right-hand rules and with phenomena whose vector direction is perpendicular to its motion or effects. Also, cross products are only meaningful in three dimensions: a simple 2D rotating system or magnetic interaction seems impossible to describe in purely 2D terms, and formulating these concepts in modern theories with extra dimensions looks hopeless. All of these challenges can be addressed by describing angular momentum, magnetic fields, and related quantities as bivectors. Instead of vector arrows, bivectors can be visualized as “tiles” with area and orientation whose components form an antisymmetric matrix. Even though they’re less familiar today, in most ways bivectors are no harder to understand than vectors and cross products, and they can be included in the curriculum in a natural, scaffolded way. Introducing this one easily visualized concept (without complicated additional structures like geometric algebra or differential forms) can help address student difficulties and provide even experts with deeper insight into this familiar physics. A change like this couldn’t happen all at once, but there are worthwhile first steps that can fit comfortably in almost-traditional instruction.

(MON-POS-G-608) | Poster Presentation Traditional | Implementing a Career Planning Module in a Physics Senior Seminar Course

Presenting Author: Kristi Concannon, King’s College

Senior exit surveys from 2016-2021 revealed that fewer than half of our graduating physics majors rated their “career advising” experience as a positive one. To address this short-coming and to better prepare our students for future careers in physics, in Spring 2022, our Physics Senior Seminar course was restructured to include a two-week career planning module. In this module, students complete self-evaluations of their skills and interests, discover how to map those abilities to a variety of physics-related jobs, utilize different databases to search for jobs across a wide cross-section of industries, construct professional resumes and cover-letters, and learn how to successfully prepare for and navigate through the interview process. The module concludes with each student participating in a mock job interview with a faculty member from outside the physics program. Student feedback on the career planning module has been very positive. This poster will highlight some of the learning goals, assignments, and assessment tools in our career planning module.

(MON-POS-G-610) | Poster Presentation Traditional | Educational Initiatives at the Quantum Ethics Project

Presenting Author: Josephine Meyer, University of Colorado Boulder / Quantum Ethics Project

Additional Author | Joan É Arrow, Quantum Ethics Project

Additional Author | Rodrigo Araiza Bravo, Quantum Ethics Project

Additional Author | Anna Knörr, Quantum Ethics Project

Additional Author | Sara E Marsh, Quantum Ethics Project

Additional Author | Zeki C Seskir, Quantum Ethics Project

As quantum information technologies (such as quantum computing and quantum sensing) move from science-fiction to “science-fact,” it is increasingly important that our workforce be literate not only in the technical aspects of quantum but in the critical thinking skills to ensure these technologies are developed ethically and responsibly. The Quantum Ethics Project is a new interdisciplinary initiative designed to promote research and education in quantum ethics: the academic study of the potential social, economic, and political implications of quantum technology. Quantum ethics aims to analyze the potential societal impacts (both positive and negative) of emerging quantum technologies to ensure they are deployed wisely and for the broader benefit of the public. We discuss education and curriculum development initiatives we are working on, why quantum ethics matters, and how quantum educators can include topics of quantum ethics in their curriculum (from a 1-hour workshop to a full-semester course).

(MON-POS-G-612) | Poster Presentation Traditional | Quantum Computing Conceptual Survey

Presenting Author: Josephine Meyer, University of Colorado Boulder

Additional Author | Gina Passante, California State University Fullerton

Additional Author | Steven J Pollock, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

The Quantum Computing Conceptual Survey (QCCS) is a research-based assessment instrument under development targeting interdisciplinary introductory coursework in quantum computing. We discuss the development and pilot process for QCCS currently underway and highlight opportunities for instructors to provide feedback on the instrument and use QCCS to evaluate student learning in your classroom.

(MON-POS-G-614) I Poster Presentation Traditional I Introducing Quantum Phenomena with Hands-On Quantum Operators

Presenting Author: J. Schober, Trinity School, NYC

Additional Author | Fernand Brunschwig, SUNY Empire State College (retired), STEMteachersNYC (Founder and past President), New York, NY

We have developed a version of the Quantum Operators invented at Harvard in the ‘60s by Kostas Papaliolios*. Our Quantum Operators are two types of 3D-printed octagonal blocks with polarizers mounted inside and Dirac symbols printed on the outside. The Quantum Operators use the behavior of polarized light in the macro domain as an analogy for the behavior of photons in the quantum domain. Explorations with the Quantum Operators stimulate thinking about measurement and the role of the observer, leading to key concepts such as quantum superposition and the collapse of the wavefunction upon measurement. When two or more Quantum Operators are arranged in sequence, the relative intensity of transmitted light is observed and connected to the Dirac notation on the blocks. Students can also predict transmission based on the Dirac notation and explore non-commutative situations. Resources for constructing, understanding, and teaching with the Quantum Operators can be found at https://stemteachersnyc.org/quantumoperators/
*J. F. Gauvin, “Playing with Quantum Toys: Julian Schwinger’s Measurement Algebra and the Material Culture of Quantum Mechanics Pedagogy at Harvard in the 1960s,” Phys. Perspect. 20 (2018) 8-42.

(MON-POS-G-616) I Poster Presentation Traditional I Making Nuclear Magnetic Resonance Resonate with Students

Presenting Author: Merideth Frey, Sarah Lawrence College

Additional Author | Colin Abernethy, Sarah Lawrence College

Additional Author | David Gosser, City College of New York

Nuclear magnetic resonance (NMR) is an important tool used in the modern STEM workforce. The recent development of inexpensive benchtop NMR spectrometers offers great opportunities for undergraduate institutions to give their students relevant research skills with this essential technique. Through the support of an NSF-IUSE grant, we have established an interdisciplinary and cross-institutional team to develop, assess, and disseminate curricular material that integrates NMR into the undergraduate science curriculum. We have been developing and testing curricular materials consisting of lab modules and associated instructional guides and online resources. As we focus on dissemination in the coming year, we would like to assess the implementation of these materials and their effectiveness in different institutional environments, with or without direct access to an NMR system. If you or any faculty colleagues may be interested in implementing any of our materials, please scan the QR code on the poster for the contact form.
Website with NMR Modules for Physics Courses: https://sites.google.com/view/makingnmr/physics-modules

(MON-POS-G-618) I Poster Presentation Traditional I How Can Temperature Rises Be Locked In? A Computational Approach to a Non-Equilibrium Situation

Presenting Author: David Syphers, Eastern Washington University

We sometimes hear that global temperatures would continue to rise for many years even if humans immediately stopped emitting all carbon dioxide. This can be counterintuitive for students reasoning from poor analogies (the pot of water stops heating when you take if off the stove), and isn’t something that shows up in analytical equilibrium temperature calculations, because it’s a non-equilibrium phenomenon. I’ll discuss how I approach this topic in a computational physics course, starting with reproducing the equilibrium calculation and then continuing to having the students code a non-equilibrium toy model of climate change showing this “locked in” temperature increase. This is an excellent early example in computational courses, because the dynamics are captured with a single-variable first-order differential equation, unlike the more complex second-order equations of classical or quantum mechanics. It’s also a good introduction to toy models that reproduce one effect of interest, and it provides a starting point for students who want to extend the model to be more realistic. As such it models actual scientific research, while also explaining a key aspect of climate change.

(MON-POS-G-620) I Poster Presentation Traditional I Shape of the Earth

Presenting Author: David Syphers, Eastern Washington University

When teaching modern astronomy, it can be difficult to convey a sense of discovery around basic facts. Students have learned from early childhood that the Earth is round and orbits the Sun. They lack the historical background to appreciate how remarkable and slow these discoveries were, and how subtle the thinking and observation had to be to come to this understanding. This can be approached via the Copernican revolution, but an alternate approach is via the shape of the Earth. Students may come in believing that everyone had thought the Earth was flat until the voyages of Columbus. It’s common in introductory astronomy to correct this by pointing to the proofs of Aristotle and the size measurement of Eratosthenes, but the subtleties are not often addressed. It’s generally not discussed how to reconcile this with Aristotle’s ordering of the elements (water higher than earth), or to explain why Columbus’s voyage was indeed impactful on our understanding of the shape of the Earth even though scholars already knew Aristotle’s proofs from millenia before. By showing the complexity of the past, and the multiple possible interpretations of observations, students can learn to appreciate the difficulty of making sense of modern observations from sparse data.

(MON-POS-G-622) I Poster Presentation Traditional I Examples from General Relativity Tutorials

Presenting Author: David Syphers, Eastern Washington University

General relativity is a topic that fascinates students, covering phenomena like black holes, quasars, the Big Bang, and gravitational waves. However, there is relatively little material that bridges the gap between qualitative “astro 101” level discussions and the full mathematical rigor of a graduate-level course. This is a daunting leap for students, and leaves many instructors without good approaches in upper-division undergraduate courses on astrophysics, cosmology, or relativity. However, we know in-class tutorials are an effective approach to teaching even difficult concepts. With this poster I’ll present specific examples from my tutorials on the metric in general relativity, and discuss how students interact with them in the classroom. This poster will go into more depth on these specific topics, contrasted with a companion oral presentation that will be a broader overview.

(MON-POS-H-702) | Poster Presentation Traditional | Decolonizing the Physics Laboratory Curriculum: Preparing Undergraduate students for Inclusion in Teaching Laboratories

Presenting Author: Filsan Ahmed, University of Albertay

It is widely recognized that the field of physics has historically been dominated by specific demographic groups, primarily white men. This has led to stereotypes and biases that can discourage underrepresented groups from taking an interest in the subject. Additionally, higher education plays an important role in shaping young adults' sense of identity and belonging within a community. Since 2022, we have implemented inclusive policies and procedures in physics laboratories, including writing laboratory experimental protocols in inclusive language, such as using gender-neutral pronouns and nouns; agree to follow the principles of equity, diversity and inclusion (EDI) before accessing the laboratory materials available on Eclass; organize an EDI quiz to mark the Day of Reconciliation and Truth; use inclusive language in the laboratory to demonstrate respect and inclusion; and hire instructors from diverse backgrounds. The integration of EDI into the physics laboratory curriculum is crucial. This effort will establish a more equitable and diverse learning environment, preparing students to become accomplished scientists and responsible global citizens.

(MON-POS-H-704) | Poster Presentation Traditional | Physicists' Attitudes Towards Career Viability Vary by Disability and Career

Presenting Author: Daniel Oleynik, University of Central Florida

Additional Author | Erin M Scanlon, University of Connecticut - Avery Point

Additional Author | Constance M Doty, University of Central Florida

Additional Author | Jacquelyn J Chini, University of Central Florida

Students with disabilities represent a significant fraction of physicists, but institutions do not currently adequately support them? We surveyed 250 physicists at national conferences and email listserv to investigate their knowledge about and attitudes toward disability. This survey, called the Disability and Physics Career Survey, asked physicists to categorize disabilities by impairment type (e.g., physical/mobility, health, cognitive, visual, hearing, and emotional/mental health), and asked them to rate whether certain careers, such as teacher and engineer, were viable or not viable for individuals with different impairments. This study focuses on perceptions of physics career viability for disabled people. We use Cochran's Q to analyze whether participants' perceptions of career viability varied across careers within a specific impairment and also across impairments within a specific career. We will interpret our findings to offer possible themes in physicists' beliefs about disability and career viability with suggestions for mentors to identify their own inclusive beliefs as well as challenge their exclusionary beliefs.

(MON-POS-H-706) | Poster Presentation Traditional | The Inclusive CATs (Classroom Assessment Techniques)

Presenting Author: Shahida Dar, Mohawk Valley Community College

Inclusive classroom assessment techniques are methods and strategies used by educators to assess student learning in a way that accommodates diverse learning needs and promotes equity.The session aims at outlining a few inclusive classroom assessment techniques used in my classroom over the years..

(MON-POS-H-708) | Poster Presentation Traditional | The Productive Physics Classroom: Creating Classroom Habits that Promote Learning, Collaboration, and Comfort

Presenting Author: Robert Krakehl, Manhasset Secondary School, Stony Brook University, Farmingdale State College

This poster presentation delves into a framework for creating a "Productive Physics Classroom", for both the secondary and post-secondary educational settings. This framework outlines several techniques for creating a class that is engaged, equitable, and always thinking. Methods for building strong habits for students - including strong questioning techniques, creating positive collaboration settings, and getting into a flow experience while working individually and collaboratively are presented. https://robkrakehl.com/

(MON-POS-H-710) | Poster Presentation Traditional | Living in the Tensions: Investigations of Gender Performativity in STEM

Presenting Author: Noah Leibnitz, Oregon State University

Additional Author | Yangquiting Li, Oregon State University

Additional Author | Smith Strain, Auburn University

Additional Author | Eric Burkholder, Auburn University

In this work, we present the results of semi-structured interviews with four women to explore how they perceive themselves with respect to three gender constructs (femininity, masculinity, androgyny), and how they believe others perceive them. All of the women highlighted the performative nature of gender in science, technology, engineering, and mathematics (STEM), citing (1) stereotypes that women are not analytical thinkers, or femininity being associated with "being stupid"; (2) the pressure to conform to the masculine norms of STEM, and (3) a pressure to perform to prove that they belong in STEM. Some of these women aligned their own perceptions of their gender with these norms, while others expressed frustration with the tension between their gender and how that is perceived by peers in STEM. This work suggests that conceptualizing gender as performance is a useful lens for understanding the oppression and underrepresentation of women and gender minorities in STEM.Ed Tech Posters II

(MON-POS-H-712) | Poster Presentation Traditional | An "interventional" summer research program for engaging and retaining STEM students

Presenting Author: Toni Sauncy, Texas Lutheran University

Additional Author | Elizabeth Woods, Texas Lutheran University

With funding from the NSF IUSE:HSI program, Texas Lutheran University has developed a robust multidisciplinary faculty-mentored undergraduate research program for summer for the past four years. The research session is shorter than a typical NSF REU but does include professional development mini-workshops and a seminar series similar to more traditional, and lengthier, summer research programs. Students are selected based on potential prioritized over GPA and present their work in a culminating final symposium that includes their families and significant others. The preliminary results of this program have been overwhelmingly positive for both student participants and faculty mentors and have been transformative for all involved. The range of research activity is broad to accommodate student interest and the program has spawned several cross-disciplinary collaborations that were uncommon in the TLU natural sciences prior to this work.

This work supported by NSF IUSE:HSI Award#1953561

(MON-POS-F-502) | Poster Presentation Traditional | Demystifying Particle Detectors with Interactive Learning Tools

Presenting Author: Richard Dube, University of Connecticut

Additional Author | Diego Valente, University of Connecticut

Additional Author | Richard Jones, University of Connecticut

Particle Identification Playground is a collection of Jupyter notebooks that teach algebra-based physics students about the working mechanisms of detectors commonly used in particle physics experiments and how these detectors can be used to identify particles. These activities open with foundational topics in particle physics, such as vectors, special relativity, and the standard model. Later notebooks have students explore different subdetectors of the GlueX detector in Hall D of Jefferson National Laboratory by analyzing and visualizing data. After completing these notebooks, students will be able to identify particles in publicly available particle physics data, which will allow algebra-based physics students to engage with particle physics research earlier in their physics careers. This poster will present several applets and visualization tools used in Particle Identification Playground activities and describe how they help students understand how various particle detectors are used.
Visit Particle Identification Playground here: https://duberii.github.io/pid-playground/

(MON-POS-F-504) | Poster Presentation Traditional | A Detection Game with Random Signals Combined with Random Noise Using Electronic Circuitry or Dice Throws

Presenting Author: Sienna Burge, 400 Granville Dr., Riva, MD 21140

Co-presenting Author | Mary Ruth Putnam, 400 Granville Dr., Riva, MD 21140

Additional Author | Murray S. Korman, Dept. of Physics, United States Naval Academy

Our electronic demonstration involves separate noise and signal loudspeakers. The detected microphone's voltage is filtered, amplified, squared, integrated, and inserted into our window comparator circuit. The output is converted into short pulses ("on" 5 volts, "off" 0 volts). Pulses are counted digitally (with an LED display) for 4 seconds in each voltage window and recorded. Change the voltage window by adjusting the high and low reference voltages. Repeat for many windows to provide the counts vs. the middle of the window. Discover a "probability" graph that changes with increasing random signal strength. Play this game with dice throws. Example: use 6 dice for signal throws and another 4 dice for noise throws. The odd spots each have a value -1 and the even spots a value of +1. After each throw of all dice record the sum of the "-1"s added to the "+1"s to generate a simulated microphone voltage.

(MON-POS-F-506) | Poster Presentation Traditional | Active Learning Python-based Interactive Notebooks for Introductory Electricity and Magnetism Concepts

Presenting Author: Belter Ordaz-Mendoza, University of Connecticut

Co-presenting Author | Niraj Ghimire, University of Connecticut

Additional Author | James Jaconetta, University of Connecticut

Additional Author | Kevin Lindstrom, University of Connecticut

Our introductory calculus-based electricity and magnetism course at the University of Connecticut is taught in Studio format, where lecture and discussion are blended to reduce lecture time and spend more time on hands-on, computer-rich, interactive in-class activities. It consists of up to 54 students per section working collaboratively in groups of three at workstations equipped with nine moveable seats each and computers, laboratory interfaces and lap whiteboards. In this work, we seek to improve the student learning experience and success in the course by integrating python-based interactive notebook activities adapted from the physics education research literature. We incorporate elements of universal design for learning into these activities for the needs of diverse learners and with the purpose of removing barriers for students.

(MON-POS-F-508) | Poster Presentation Traditional | Project STEMinAR: Physics Simulations in Augmented Reality

Presenting Author: Garrett Matthews, University of South Florida - Tampa

Additional Author | David Rosengrant, University of South Florida - St. Petersburg

Additional Author | Karina Hensberry, University of South Florida - St. Petersburg

Additional Author | Nancy Sharfun, University of South Florida - St. Petersburg

Additional Author | Kelly Navas, University of South Florida - St. Petersburg

We are developing a new augmented reality app for mobile devices to be used in the classroom. The app is called STEMinAR. Within this app users will find simulations for Newton's Cannon, Newton's Laws, Rotational Motion, Thermodynamics, and Optics. Future simulations are still to come. We will also be highlighting curricula created which follows the Investigative Science Learning Environment framework. The simulations track a free, downloadable cube, allowing the user to interact directly within the virtual environment. A strength of these simulations is that users have access to multiple variables. Users are then provided real-time data representations, giving them the ability to observe the results from changing the input variables. In this presentation, we will demonstrate the simulations and share initial data from the simulations. Support for this work is provided by an IUSE grant from the National Science Foundation.

(MON-POS-F-510) | Poster Presentation Traditional | Developing Interactive Multimedia Resources for Physics Education

Presenting Author: Rudra Kafle, Worcester Polytechnic Institute (WPI)

Co-presenting Author | Thomas Noviello, Worcester Polytechnic Institute (WPI)

Research shows that the integration of multimedia into instructional activities improves student learning because information mostly flows into our brain via auditory and visual channels. Additionally, proper integration of multimedia tools into our instructional activities will make the learning process fun and engaging. We have been developing short physics educational videos and analyzing them pedagogically in collaboration with WPI students. Not only is the development of these videos beneficial to future students, but also to the student developers. These projects are counted as interactive qualifying projects (IQPs) which are junior-level requirements for graduation at WPI. The students who create these resources gain a deeper understanding of physics concepts after completion of the projects. We will present some recently completed projects, their impact on students and their relevance to the physics community.

(MON-POS-F-512) I Poster Roundtable I Systematic Comparison of Ultraviolet vs. White Light for Lightboard Illumination

Presenting Author: Craig Looney, Merrimack College

Since Peshkin's invention of the original open-hardware lightboard, tempered low-iron glass has been the preferred lightboard writing surface: low-iron for maximal transparency, tempered for safety and durability. Unfortunately, the tempering process often leaves marks on the glass that become highly visible when illuminated with edge-mounted white LEDs. One obvious idea is to illuminate the glass with UV LEDs; the UV light should cause the fluorescent marker writing to visibly fluoresce, while UV light scattered by defects should be invisible. McCorkle and Whitener (2017, 2020) reported a qualitative performance enhancement for near-visible UV blacklight illumination, but no systematic investigations have been reported. I have therefore undertaken a systematic comparison of UV vs. white-light lightboard illumination. My initial results indicate that near-visible blacklight UV LEDs do indeed provide superior masking of tempering-related defects; these and further results will be presented.

(MON-POS-F-514) I Poster Presentation Traditional I Can AI Perform Qualitative Data Analysis?

Presenting Author: Praveer Sharan, Purdue University

Additional Author | Liam McDermott, Rutgers University

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Artificial intelligence (AI) utilizes advanced language models to analyze language patterns, extract meaningful insights, and make informed decisions across various applications. Are AI models sophisticated enough to now perform qualitative data analysis? This study utilizes several common AI models to perform a basic thematic analysis of introductory physics for life science majors (IPLS) students' understanding of dropping a ball. This poster compares the different AI language models' ability to identify themes, the time required for analysis, ease of use, and the accuracy of trend identification. Implications for the future of qualitative analysis will be discussed. This research is supported by NSF award # 2021273.

(MON-POS-F-516) I Poster Presentation Traditional I ChatGPT's Ability to Interpret Kinematics Graphs Is Far From Being Human-like

Presenting Author: Giulia Polverini, Uppsala University

Additional Author | Bor Gregorcic, Uppsala University

The ability to interpret graphs in kinematics is crucial for students, since graphs are one of the most commonly used representations. Assessment tools, like the multiple-choice Test of Understanding Graphs in Kinematics (TUG-K), have been developed to test students' understanding of the topic. Because of the recent ability of ChatGPT-4 to process image data as input, it is now possible to study how the chatbot performs in such a test and compare it with students. A quantitative analysis shows how the chatbot performs very similarly to students on average, but with a much narrower distribution of the scores and a more spread percentage of correct responses. On the other hand, a qualitative analysis reveals significant differences in how students and the chatbot visually interpret graphs and reason about them.

MON-POS-F-518) I Poster Presentation Traditional I Understanding the User Experience in an Augmented Reality App with Data Collection

Presenting Author: Sophia Pavia, Siena College

Additional Author | Jamie Martino, Siena College

Additional Author | Michele McColgan, Siena College

Additional Author | Graziano Vernizzi

Analytics provide insights into user experiences in mobile apps. In augmented reality (AR) apps designed to help students visualize physics concepts, data collection provides insights into how students interact with the app while learning about abstract and 3D physics concepts, such as magnetism. Analytics enable app developers and physics education content creators to assess app performance, user behaviors, and usage trends over time. This poster presents data on the scenes visited, buttons pressed, and interactions with the image target.

(MON-POS-F-520) I Poster Presentation Traditional I Using Augmented Reality to improve student understanding of Physics and Engineering Concepts

Presenting Author: Mohamed Shahabuddeen, Seina College

Additional Author | Ajay Singh, Siena College

Additional Author | Kamyar Pashayi, Siena College

Additional Author | Michele McColgan, Siena College

The MARVLS App is an augmented reality app for students to explore physics and engineering models of abstract or 3D concepts. MARVLS is an acronym for Manipulable Augmented Reality Visualizations to Learn Spatially. Concepts are selected that are difficult for students to visualize. There is an expectation that students can connect 2D representations to the 3D models they represent. The App was created and designed to provide scaffolding to connect representations such as 2D images and mathematical equations to the 3D models or abstract concepts they represent in physics and engineering. Several physics and engineering augmented reality models will be presented in this poster on topics in optics, circuits, and materials science.

(MON-POS-F-522) I Poster Presentation Traditional I Using Augmented Reality to Improve Student Understanding of Air over a Foil

Presenting Author: Fasiha Khaliq

Additional Author | Mark Rosenberry, Siena College

Additional Author | Michele McColgan, Siena College

The equations determining 3D fluid flow past an airfoil have been known for many decades. Many, such as Prandtl's lifting line model, are still a good illustration of the basic flow pattern, even in the absence of viscosity. We seek to use these equations to create insightful visualizations of the air flow, illustrating the vorticity in a different representation than the symbolic math. Though potentially of interest in Classical Mechanics, this convenient augmented reality app is intended primarily for use in a first engineering course in fluids or aerodynamics.

(MON-POS-F-524) I Poster Presentation Traditional I Using Gesture Detection of the Right-Hand-Rule in an Augmented Reality App

Presenting Author: Howard Li, Siena College

Additional Author | Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

Many physics and engineering concepts require spatial visualization skills to understand abstract and 3D concepts. Educators have developed hand gestures to help students relate 3D physics vector concepts to each other. Vector equations usually involve cross products and the variables in the equations represent and connect these physical quantities. For example, educators teaching magnetism use many different right-hand-rules to connect current (direct and induced) and the magnetic field. There is an opportunity to scaffold these right-hand-rule gestures with gesture detection. In this poster, we present an augmented reality app that includes gesture detection to recognize if a student is properly displaying the right hand rule appropriately in different physics scenarios.

(MON-POS-F-526) | Poster Presentation Traditional | 2D platformer game in a mobile App to reinforce magnetism concepts

Presenting Author: Neha Matta, Siena College

Additional Author | Taylor Conroy, Siena College

Co-presenting Author | Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

Connecting 2D representations of 3D physics concepts is a complex process for students. This poster will describe the design of a 2D platformer educational game for smartphone apps. In the game students will direct their "charged" character to navigate a puzzle game with 2D representations of electric and magnetic fields.

Grading and Assessment Posters II

(MON-POS-I-802) | Poster Presentation Traditional | Ungrading! Using Contract-grading to Support Student Learning in Introductory College Physics Classes

Presenting Author: Jon Gaffney, Utica University

Co-presenting Author | Paul Hutchison, Grinnell College

Traditional methods of grading provide a type of motivation that gets in the way of learning more than it provides support (Schinske & Tanner, 2014). Those methods (1) diminish students' interest in what they're learning, (2) encourage the easiest possible task, and (3) reduce the quality of student thinking (Kohn, 2011). Because we are required to submit term grades, we have each begun to use a version of contract-grading in an introductory-level course. Because of the considerable differences in the student populations of our classes (an algebra-based course for construction management majors and an inquiry-based course for non-majors), we have approached our contracts with students from quite different directions. Thankfully, we both report that our efforts have not been disasters. In this poster we describe how we implement our different versions of contract-grading, how we feel they have played out, and student perceptions of our ungrading systems.

(MON-POS-I-804) | Poster Presentation Traditional | Investigating the Impact of Post-exam Grade-adjustment Practices in Introductory Physics

Presenting Author: Nicholas Young, University of Georgia

Additional Author | Rebecca L Matz, University of Michigan

Additional Author | Eric F Bell, University of Michigan

Additional Author | Caitlin Hayward, University of Michigan

Exams play an outsized role in typical introductory physics courses, often contributing over half of students' final grades. Various studies have explored how changes to physics exam grading practices could lead to more equitable grade outcomes. This is especially important given the documented gender- and race-based grade inequities in physics and because grades play an important role in determining whether students can get into and stay in the major of their choice, keep their financial aid and scholarships, and ultimately graduate from the university. In this study, we sought to understand how different schemes of exam grade aggregation affected final grades. We examined exam grade data from students enrolled in a first-semester, introductory calculus-based physics course at a large, research-intensive Midwestern university over a 6-year period. We find that most students earn consistent grades across exams or that they earn lower grades on subsequent exams. We discuss the implications of this result for various post-exam grade practices such as dropping the lowest exam grade or giving different weights to each exam based on performance.

Intro Posters II

(SUN-POS-D-402) | Poster Presentation Traditional | Simulations and Activities for Ultrasound Imaging

Presenting Author: Ralf Widenhorn, Portland State University

Additional Author | Bethe Scalettar, Lewis & Clark College

At Lewis & Clark College and Portland State University, we have developed interdisciplinary undergraduate science courses that connect biomedical imaging techniques to basic physics principles. We will present the first steps of a project that aims to further enhance the imaging physics curriculum through interactive simulations of different imaging modalities used in medicine. Eventually, the simulations and associated activities will be organized into four modules on ultrasound imaging, radiography, nuclear imaging, and MRI, and be made available on open education platforms like the Living Physics Portal. Over the next couple of years, we will research how these modules affect student engagement and grasp of concepts fundamental to imaging physics. In this presentation, we will present the prototypes of this project with examples from ultrasound imaging, covering topics like Doppler ultrasound, lateral and axial resolution, contrast, and acoustic impedance. The simulations can be used in an upper-level interdisciplinary undergraduate physics course and selected content is also appropriate for introductory physics courses for life science students. This work is supported by NSF IUSE Grant DUE-2315742

(MON-POS-D-404) | Poster Presentation Traditional | The Skateboard Rocket

Presenting Author: Carl Mungan, United States Naval Academy

Example Problem 8-3 in Tipler/Mosca "Physics for Scientists and Engineers" Sixth Edition analyzes a rocket consisting of a 40-kg girl on a 3-kg skateboard (which rolls without friction and drag along level ground) who is holding two 5-kg weights. Each weight is thrown horizontally backward at an exhaust speed of 7 m/s (relative to the skateboard) to propel the board forward. Consider four different ways of throwing the weights:
(1) The exhaust speed is relative to the final speed of the rocket after a throw, where the two barbells are thrown sequentially one after the other. (2) The exhaust speed is relative to the final speed of the rocket after a throw, where the two barbells are thrown simultaneously as one combined package. (3) The exhaust speed is relative

to the initial speed of the rocket before a throw, where the two barbells are thrown sequentially one after the other. (4) The exhaust speed is relative to the initial speed of the rocket before a throw, where the two barbells are thrown simultaneously as one combined package.
Every case gives a different final speed for the girl. Can you correctly predict the order of the final speeds of the girl for these four cases?

(MON-POS-D-406) | Poster Presentation Traditional | Newly Updated Tutorials in Introductory Physics

Presenting Author: Anne Alesandrini, University of Washington

Additional Author | Charlotte Zimmerman, University of Washington

Additional Author | Paula Heron, University of Washington

Additional Author | Peter Shaffer, University of Washington

The University of Washington Physics Education Group has been making research-based curriculum for many years. Previous editions of Tutorials in Introductory Physics have been used in university physics courses across the United States and internationally. We will be releasing newly created, updated, and adapted versions of the tutorials with corresponding instructor's guides. This poster will feature the tutorials updated to complement contemporary physics textbooks (specifically Mazur's Principles and Practices of Physics) in calculus-based courses. The corresponding instructor's guides will include the aims, expected challenges, and helpful suggestions for each tutorial. We will also highlight ways for instructors interested in using the tutorials to connect and find support.
This work is supported by the National Science Foundation, under grant No. DUE-1821032.

(MON-POS-D-408) | Poster Presentation Traditional | Rethinking Math Prerequisites for Introductory Physics Majors

Presenting Author: AJ Richards, The College of New Jersey

Additional Author | Angela M Capece, The College of New Jersey

We implemented a curriculum change at our institution, in which we enroll in our calculus-based Physics I course the first-year physics majors who placed into the pre-calculus level, in order to improve their retention and persistence in the major. Prior to the intervention, around 10% of non-calculus-ready students were retained within the major. Following the intervention, more than half of the students have either successfully graduated with a physics degree from our institution or are currently progressing through the major. This intervention can help address demographic disparities in physics education, since women, students from ethnic minorities, and first-generation students are overrepresented in the non-calculus-ready group. In this paper we present the outcomes of the intervention, describe the strategies employed to accommodate and support non-calculus-ready students, and hopefully offer a blueprint for departments seeking to create more inclusive learning environments that lead to better retention.

(MON-POS-D-410) | Poster Presentation Traditional | Using Randall Munroe's What If? in a Freshman Seminar Course

Presenting Author: Andrew Richter, Valparaiso University

At Valparaiso University, we offer a 1 credit freshman seminar course for incoming physics majors. I have been using Randall Munroe's "What If?" as a way to show students that even freshman physics and math can be used to generate solutions for interesting and quirky problems. As a companion text, I use "Guesstimation" by Weinstein and Adam, which helps train students in finding approximate solutions. Each class period involves examining several What If? entries and Guesstimation problems, with discussions about the physics and math behind the solutions. We also engage with library staff to learn how to find and cite reputable sources. As a final project, each student poses and then answers their own What If? question, giving a presentation for the class. In this talk, I will discuss some of the benefits as well as some of the problematic issues, presenting several examples of in-class exercises and final projects.

K-12 Posters II

(MON-POS-A-102) | Poster Presentation Traditional | Physics Pen Pals: Authentic Scientific Collaboration Across Classrooms

Presenting Author: Allison Daubert, Montrose Schoo

Co-presenting Author | Danielle Buggé , West Windsor-Plainsboro High School South

During the 2023-2024 school year, high school students at the Montrose School in MA and West Windsor-Plainsboro High School South in NJ engaged in an authentic scientific communication project. Students at both schools were taught by teachers trained in using the Investigative Science Learning Environment (ISLE) approach. Each school performed four ISLE experiments and students collaboratively wrote up their findings as laboratory reports. These reports were then shared with students at the other school, for peer review. After receiving peer feedback, students had the opportunity to revise their work. Visit our poster to speak with our high school students and learn about their experiences engaging with the peer-review process.
Funding for this project was provided by a Toshiba America Foundation grant.

(MON-POS-A-104) | Poster Presentation Traditional | Could You Outrun a Dinosaur?

Presenting Author: Patrick Englehardt, The Winchendon School

Could you outrun a Dinosaur? According to current research the answer is some yes, but that isn't the real interest of this study. Rather the more interesting question is "How do we know you could, and how can we teach our students about finding the answer"? While dinosaur's are no longer around, they have left behind all of the evidence needed. Dinosaur trackways are found all over the world, and even if you don't live near one you can create your own. By studying the trackways you can introduce a real life one dimensional kinematic problem that requires students to design their own experiments, collect large amounts of data and hypothesize what the relationship is between track size, leg length and stride lengths. Students could even take what they have learned from this study and apply it to modern trackways like that found on the serengeti.

(MON-POS-A-106) | Poster Presentation Traditional | AP Physics: Upcoming Changes & New Experiments

Presenting Author: James Lincoln, SCAAPT

Additional Author | Bryn Bishop, SCAAPT

2024-25 will see a redesign of every AP Physics exam, the largest changes coming for AP Physics 1 and AP Physics 2. On this poster, I provide an overview of what's new for all exams and provide experiment ideas to help meet the new curricular requirements. In AP Physics 1, we are adding a unit on Fluids, in AP Physics 2 we are adding Waves and Sound. But what might this look like? This poster emphasizes an activity and lab-driven curriculum with many examples provided.

(MON-POS-A-108) I Poster Presentation Traditional I PhysicsQuest: Plasma – A Mysterious Matter Free Materials for Middle and High School Students

Presenting Author: Nicole Schrode, APS

Co-presenting Author | Jessica Eskew, Auburn University

PhysicsQuest is a hallmark of Public Engagement at the American Physical Society (APS), serving teachers and students for almost 20 years. We aim to engage children in inquiry-based physics activities to demonstrate physics as fun and accessible. Similarly, we hope to empower teachers to teach physics with more student-centered practices about current topics in physics research. We also incorporate relatable narratives of underrepresented scientists working in the field to inspire students to continue to pursue careers in science. Come learn about PhysicsQuest: Plasma - A Mysterious Matter, lab kits for four hands-on activities, designed for a middle school audience. For each of the activities we provide: guides for students and teachers, explanation of the science, modifications and differentiation, resources (videos and other tools), connection to NGSS, and a focus on DEI learning strategies in partnership with the STEP UP Program.

(MON-POS-A-110) I Interactive (e.g. panel, round table discussion, hands-on activity) I Developing Models: Thermal Equilibrium & Momentum Conservation

Presenting Author: Ross Gunderson, Eastern York High School

Helping students make sense of systems reaching thermal equilibrium can sometimes be a challenging process. Specific heat capacities make the phenomena even more complex. In this workshop, a model for thermal equilibrium using thermal energy charts will be presented, in order to aid students in developing an understanding for what is happening during thermal energy exchange. These models share similarities to momentum conservation as well, demonstrating the cross cutting concept for how systems can share a similar model.

(MON-POS-A-112) I Poster Presentation Traditional I Learning From Drawings: Using TYLeS to Survey Educational STEM Programs

Presenting Author: Patrick Morgan, University of Massachusetts Amherst

I led a group of students at a hands-on event for a Girl Scout STEM Expo in October of 2023, at which we had 3rd-6th grade school children rotate between three stations. The stations were each themed (Optics, Waves, Electrostatics) and at each station students would learn about the topic for 4-5 minutes, get to play with the science toys for 5-7 minutes, and then draw what they learned for 2-3 minutes. Students were asked to take their drawings home with them, but some drawings were left behind. This incidental data set I conducted a qualitative review of using the Thank You Letter Surveys (TYLeS) methodology in order to discern what students were drawing, and to learn what they were learning.

(MON-POS-A-114) I Poster Presentation Traditional I Teacher Survey: State of Oregon High School Physics

Presenting Author: Tamar More, University of Portland

Additional Author | Kenneth C Walsh, Oregon State University

We report preliminary results from a survey of Oregon high school physics teachers for a pulse on the state of OR HS physics, the expectations of our HS physics teachers, and how OR AAPT might support teachers. Teachers of 9th grade physics, traditional introductory physics, and advanced physics and from a wide range of school settings were surveyed. We will provide an update on the survey results and discuss next steps.

(MON-POS-A-116) I Contributed Talk (12 Minutes) I Reaching Reluctant Learners

Presenting Author: NADENE KLEIN, Douglas County School District

Some students are labeled at-risk and have been unsuccesful in our science classes. This talk will explore why this may be and how to engage these reluctant learners. Several strategies, techniques, tricks, and tips will be shared that have been successful in both alternative and traditional settings.

(MON-POS-A-118) I Poster Presentation Traditional I Spectrum Science Workforce Development Project

Presenting Author: Valarie Bogan, National Radio Astronomy Observatory (NRAO)

Radio frequencies serve various purposes such as scientific discovery and wireless communication. The utilization of these energy waves is on the rise, leading to a growing number of job opportunities. The National Radio Astronomy Observatory has created the Spectrum Science and Workforce Development Project to aid educators in preparing individuals for these positions. Starting at the middle school level, the project offers eight lesson plans to enhance students' understanding and curiosity about radio waves. Alongside these structured lessons, there is a citizen science initiative enabling students to extend their interest beyond the classroom by investigating radio waves in their local area using a cell phone app or an RTL-SDR device. As students advance to high school, they have access to an additional 19 lessons to further cultivate their fascination with radio waves. For those who decide to pursue a science degree in college, there are six undergraduate digital badge courses available on our platform, SuperKnova. These modules can also be integrated into college courses by professors. The resources provided do not need to be followed in a specific order; individuals can select resources from our catalog as desired, and all materials are offered at no cost.

(MON-POS-A-120) I Poster Presentation Traditional I From Following Instructions to Freely Exploring: Analyzing Students' Interactions While Computational Modeling in a High School Physics Classroom

Presenting Author: Luke Conlin, Salem State University

Co-presenting Author | Bridget Knight, Salem State University

Co-presenting Author | Aaron Dwyer, Salem State University

Co-presenting Author | Emi Pilla, Salem State University

Researchers and instructors alike are looking to integrate computation into high school physics classrooms. Our research-practice partnership designed and piloted a curriculum unit where physics students model Earth's climate. Students' improvement on writen pre-posttests demonstrates that the unit helped them learn both physics concepts and computational modeling practices. To understand students' learning process, we analyze video data of their classroom interactions. We find students often learn when they spontaneously go beyond just following the instructions, for example, to investigate whether the model's surprising behavior is a bug in the code or a feature of the Earth's climate.

(MON-POS-A-122) I Poster Presentation Traditional I Students' Development of Quantum Concepts Through Quantum Board Games

Presenting Author: Benjamin Dreyfus, George Mason University

Additional Author | Nancy Holincheck, George Mason University

Additional Author | Jessica L Rosenberg, George Mason University

We developed a quantum version of the board game Chutes and Ladders, to be played with a standard Chutes and Ladders board. The quantum version of the game illustrates concepts of superposition, probability, measurement, and (in the more advanced version) entanglement. We have run this activity with multiple groups who are new to quantum concepts including middle school students, high school students, undergraduates, and K-12 teachers. With some of the groups, Some of the groups designed their own quantum tabletop games after they learned about quantum concepts and played quantum Chutes and Ladders as an example. We present the evolution of the game as it has been adapted over time. We also present initial research results based on video data from students playing (and designing) these games, and identify conceptual themes that emerge from the interactions among students around this activity.

(MON-POS-A-124) I Poster Presentation Traditional I Design Dilemmas: A Way of Understanding Teacher Approaches to Co-designing Pphysics Curricula

Presenting Author: Katarzyna Pomian Bogdanov, Northwestern University

Recent science reforms call for a shift in classrooms from students learning about science to students figuring out science concepts and practices. Teachers often rely on curricular materials as support for implementing these reform-based science initiatives. Importantly, there are curricular materials that are being created by teachers alongside researchers leading to more sustainable curricula. But how do teachers and researchers work together to make necessary decisions about what to include in the curricular materials? I explore a co-design space where physics teachers work on co-designing a storyline-driven physics unit with curriculum designers. I specifically explore design dilemmas as probelms where there are multiple possible directions the team can pursue. I find how three different teachers use their curricular values—criteria that reveal key directions—to resolve these design dilemmas.

(MON-POS-A-126) I Poster Presentation Traditional I Building Sustainable Physics Education Communities: Network Analysis of the STEP UP Program's First Cohort

Presenting Author: Saksham Prajapati, APS

Co-presenting Author | Meg Healy, APS

This study presents a network analysis of the first cohort of the STEP UP Advocates under the Gordon and Betty Moore Foundation grant. STEP UP is a national community of physics educators and researchers aiming to inspire young women to pursue physics. Our goal was to identify the most effective model for expanding the program by recruiting more teachers. We tested a regional model in Los Angeles, New York City, and Chicago. In this model, regional coordinators, ambassadors, and university faculty collaborate to recruit, train, and establish a regional community of STEP UP teachers. The intent is to foster sustainable communities that develop localized activities and resources. Using network analysis tools, we examined the connectivity of teachers from these regions both before and after participating in the cohort, as well as their affiliations with other networks. We will discuss changes in the network, or lack thereof, in the networks' interconnectivity and integration within and across regions. We invite discussion and insights on alternative methods of network analysis to further assess the sustainability and impact of the STEP UP program on local communities.

Labs/Apparatus Posters II

(MON-POS-E-452) I Poster Presentation Traditional I The New Method to Measure Medium Material's Index of Refraction Based on Optical Principle of Rainbow

Presenting Author: SHIHONG MA, Department of Physics / Fudan University

Additional Author | QISI WANG, Department of Physics / Fudan University

On the basis of optical principle of rainbow, a new method to measure material's index of refraction is applied and a set of experimental instruments applying this method is worked out. With the instruments, the optical phenomenon of rainbow in physics laboratory can be used to simulate easily which helps us to understand the optical essence of rainbow in a deeper way, and get the index of refraction at the same time.

(MON-POS-E-454) I Poster Presentation Traditional I Optical Trapping – An Advanced Undergraduate Laboratory Experiment Spanning the Disciplines of Physics and the Life Sciences

Presenting Author: Aaron Pilarcik, Massachusetts Institute of Technology

Optical Trapping, a modern experiment in biophysics, allows students in the advanced undergraduate physics teaching laboratory to learn principals of both physics and the life sciences. The Optical Trap uses infrared laser light to trap biological samples ranging from plant vesicles to bacteria. Students can succesfully quantify and measure ultrasmall forces, of the piconewton scale, such as the strength of the myosin motors transporting vesicles along actin fibers in onion cells, and the forces exerted by flagella in the swimming motion of Escherichia coli bacteria.

(MON-POS-E-456) I Poster Presentation Traditional I Measuring the Refractive Index Dispersion of a Glass Prism With a Six-Beams Laser in Five Ways on One Platform

Presenting Author: Eugenii Donev, Austin Peay State University

Additional Author | Michael R. Graff, Austin Peay State University

Additional Author | Jair Martinez, Austin Peay State University

We describe a student-driven project that involves constructing a versatile optical setup based around a novel laser module with six colinear beams of different wavelengths, and using the setup to measure the dispersion of the refractive index of a glass prism by five different methods: angle of minimum deviation, total internal reflection, Fresnel reflectance, Brewster's angle, and rotating analyzer ellipsometry. This suite of experiments and concomitant computations can be adapted to undergraduate projects of various lengths and depths, ranging from two or three advanced laboratory sessions to summer-long student research experiences.

(MON-POS-E-458) | Poster Presentation Traditional | A LEGO Model of the Kibble Watt Balance as a student project and a group study class

Presenting Author: Tatiana Allen, University of TN - Chattanooga

Additional Author | Matthew L. Boone, University of TN - Chattanooga

In 2019, the kilogram was redefined based on the fixed value of the fundamental Planck's constant, therefore eliminating the need for the International Prototype of Kilogram. The apparatus that realizes the kilogram using Planck's constant is based on the idea of Bryan Kibble to balance the weight of the object by the electromagnetic force generated by the current-carrying coil immersed in a magnetic field. The apparatus is housed at NIST under clean-room conditions and can measure a kilogram within a few parts in 108. In 2015, a LEGO model of the Kibble Balance was constructed by NIST scientists [1] and there have been several attempts around the world to replicate it. We constructed a LEGO Watt Balance model as a research project funded by the SPS National grant for the UTC chapter of the Society of Physics Students. Later, it became an experiential learning 4000-level class. By working in collaboration with NIST scientists, we improved the design and participated in writing new python code for the machine. We believe this is a very good undergraduate project, even for a small physics department. We will share the lessons we have learned while making this inexpensive table-top model capable of measuring gram-level masses with 1% uncertainty.
. L. S. Chao et all, American Journal of Physics 83, 913 (2015); doi: 10.1119/1.4929898

(MON-POS-E-460) | Poster Presentation Traditional | Computing the Tension: An Activity Theoretic Analysis of a Computational Physics Lab

Presenting Author: Luke Nearhood, Oregon State University

Additional Author | Patti Hamerski, Oregon State University

Computational Physics is a key part of the landscape of 21st century physics. However there has been limited research on effective teaching techniques in computational physics. This is especially true of upper division lab courses, where practicing physics can look very different to introductory courses, as students integrate into the physics community and develop their physics identity. We conducted interviews of students in a one-credit junior level computational physics lab course at a large public research university. We analyzed these interviews through the framework of Activity Theory. In so doing we sought to identify tensions in the activities of the course and thus where improvements might be made, and to understand the general dynamics and character of the course as it currently exists. We identified tensions between group work expectations, building proficiency at computing, and other aspects of the course. The specific contextual features of this computational physics lab add detail and nuance to our findings, and may thus provide insight into how we ought to structure computational physics labs.

(MON-POS-E-462) | Poster Presentation Traditional | Mysterious meteorite NWA 13188: Could it have been Launched from Earth During a Volcanic eruption?

Presenting Author: Andrei Blinkouski, Penn State Abington

Additional Author | Alexander Malandra-Martin , Penn State Abington

Additional Author | Adam Pohl, Penn State Abington

The chemical composition of meteorite NWA 13188 shows similarities to that of volcanic rocks on Earth. In this project, we use a simple aerodynamic model to investigate the possibility that the meteorite NWA 13188 could have been launched from Earth during a volcanic eruption.

PER Posters II

(MON-POS-J-PER102) | Poster Presentation Traditional | Supporting Change in Physics Undergraduate Programs Through the Departmental Action Leadership Institute

Presenting Author: Robert Dalka, University of Maryland, College Park

Additional Author | Chandra Turpen, University of Maryland, College Park

Additional Author | Diana Sachmpazidi, University of Maryland, College Park

Additional Author | Joel C Corbo, University of Colorado, Boulder

Additional Author | David A Craig, Oregon State University

In recent years, many departments are seeking to make changes to their undergraduate physics programs to improve the student experience and sustain or grow their program. To support this work in departments, the Departmental Action Leadership Institute (DALI) was created within the Effective Practices for Physics Programs (EP3) initiative. Each participating program sends a pair of faculty members (change leaders) who attend ongoing DALI meetings for one year to learn about and implement effective change practices. Change leaders build a team who identifies the challenges within their departments and pursues collective change efforts. In this poster, we share the essential factors for the success of DALI through experiences of about 25 change leaders and their DATs across four DALI cohorts. The outcomes of this program are tracked through DALI change leaders and DAT members' interviews, fieldnotes, and surveys. These outcomes span areas such as change leaders' facilitation skills, faculty-student partnerships, and how joint sense-making about data is informed by DALI. Additionally, we will share change leaders' experiences of factors that support or challenge the sustainability of their change efforts. This work has implications for the development of change leadership and the evolving efforts within the physics community to improve undergraduate education.

(MON-POS-J-PER104) | Poster Presentation Traditional | Detecting Physics Preservice Teachers' Visual Attention Under Prediction and Nonprediction Conditions with Eye-tracking Technology

Presenting Author: Qiuye Li, South China Normal University & Ohio States University

Co-presenting Author | Lei Bao, Ohio States University

Additional Author | Shaona Zhou, South China Normal University

In science education, it is vital for teachers to consider students' academic and emotional needs. Teachers' prediction of students' learning states has been commonly regarded as an indicator to measure that competence to understand students. This study aimed to explore the outcome and the process of prediction to reflect teachers' pedagogical content knowledge. The study was to detect the differences in preservice teachers' eye movement behaviors with eye-tracking technology between the prediction group and nonprediction group. The prediction group predicted the option students will most likely choose for a given question, while the nonprediction group solved the problems on their own. The result showed that preservice teachers in the prediction group were more considerate of students' ideas and review the information among different areas of interest when they were required to detect the problem from the perspective of students. In the prediction group, preservice teachers with positive prediction focused more on the correct option repeatedly, while those with negative prediction tended to inspect carefully within each incorrect option. In addition, successful and unsuccessful problem solvers in nonprediction group responded to problems in a different manner, in which successful problem solvers paid more attention to inspecting information from options, including both correct option and incorrect option

(MON-POS-J-PER106) | Poster Presentation Traditional | Interpreting and Understanding Learning Assistants' Experiences from Personal Reflections

Presenting Author: Benjamin Dreyfus, George Mason University

Additional Author | James S Barnes, George Mason University

Additional Author | Tina M Bell, George Mason University

Additional Author | Mary Crowe, George Mason University

Additional Author | Rebecca M Jones, George Mason University

Additional Author | Kelly L Knight, George Mason University

We present initial results from a 5-year study of written reflections by Learning Assistants (LAs). Our LA program includes around 100 LAs each semester, in physics, astronomy, and 7 other STEM disciplines. All returning LAs submit written reflections at the beginning of the semester about their goals for the semester, and at the end of the semester about whether and how these goals were achieved. This corpus of data documents the successes and challenges that LAs encountered across a variety of instructional settings. It includes LAs' perspectives on the ways that courses were transformed during the early COVID pandemic and the return to in-person instruction. We share some of the themes that emerge in physics and astronomy in particular, and across STEM disciplines.

(MON-POS-J-PER108) | Poster Roundtable | A Model of Scientific Thinking Development

Presenting Author: Janelle Bailey, Temple University

Additional Author | Doug Lombardi, University of Maryland

Additional Author | Gale M. Sinatra, University of Southern California

Additional Author | Lucas P. Butler, University of Maryland

Scientific thinking is a key contributor to our information- and technology-rich society. Despite numerous studies relating to scientific thinking, a comprehensive theory about how learners advance in this area has not yet been developed. We have used prior work, both theoretical and empirical, in educational psychology and science education to propose a pathway toward a comprehensive model of scientific thinking. Informed by research in conceptual change, active learning, credibility and plausibility judgments, scientific engagement, and empirical thinking development, we outline a model that brings together various ideas that can contribute toward the creation of a novel theory. Three areas–seeking and understanding scientific knowledge, engaging in scientific knowledge building, and becoming an agent of scientific meaning–are fused through attitudes, beliefs, affect, and identity to contribute to both scientific literacy for all and disciplinary scientific expertise for those who choose to pursue it.

(MON-POS-J-PER110) | Poster Presentation Traditional | The Relation of Epistemic Cognition, Metacognition, and Gender to Physics Identity: The Mediating Role of Physics Self-efficacy

Presenting Author: Yaren Ulu, Texas Tech University

Additional Author | Sevda Yerdelen-Damar, Bogazici University

This study aimed to investigate how epistemic cognition in physics and metacognition, together with three dimensions of physics identity framework– recognition, physics self-efficacy, and interest– predicted the overall physics identity of Turkish high school students and to investigate gender differences in study constructs. The data were analyzed using structural equation modeling. The model fitted the data well, motivating intervention studies to test the causal relations proposed in the model. Recognition and interest directly predicted physics identity and mediated the relation of physics self-efficacy to it. Metacognition and epistemic cognition predicted physics identity through physics self-efficacy. There were significant direct and indirect relations among metacognition, epistemic cognition, self-efficacy, recognition, and interest. Furthermore, while no gender difference was observed in metacognition and epistemic cognition in physics, male students scored higher than female students in other factors. However, the mediation analysis indicated that gender differences in physics self-efficacy might explain gender differences in physics identity, recognition, and interest. The results could motivate future interventions testing the effect of metacognitive and epistemic activities on both physics self-efficacy and identity, and the interventions testing whether practices that reduce the gender gap in physics self-efficacy will help eliminate the gender gap in physics identity, recognition, and interest.
This study was accepted by APS Physical Review Physics Education Research.
https://journals.aps.org/prper/accepted/3c07dLf6N3f1ae02004d8d319b6c111df837b8ab1

(MON-POS-J-PER112) | Poster Presentation Traditional | Progress Report on our new Life After Graduation Course and the Presume Program

Presenting Author: Robert Brown, CWRU

Additional Author | Charlotte L Bimson, CWRU

The important fact is that most people with a physics degree will have non-academic careers. We finally addressed this head-on with a new course with different weekly visitors from different industries telling how their BS or MS or PhD prepared them. Goals include awareness, elective choices, internships, networking, job-specific resumes and, for our youngest students, a practice or pre-resume or "preresume." Representative of the unanimously positive comments is the following: "This is the most unique course I have ever taken in my grad, undergrad life. It made me realize so many things and gave me time to prepare myself for the future. I think this course should be offered every year." A junior physics major, and a faculty co-authored four presentations during this past academic year describing this new course offered first in the Spring of 2023 and repeated this past Spring. The presentations were made at the national AAPT meeting in New Orleans (January 2024), the national APS in Minneapolis (March 2024) and at the regional APS (October 2023) and AAPT (March 2024) meetings. This is a followup progress report as we prepare for our third year of offereing this unprecedented offereing that has changed our students' - and faculties' - lives.

PER: Assessment Posters II

(MON-POS-N-PER502) | Poster Presentation Traditional | Investigating Context Dependence of Introductory and Advanced Student Responses to Introductory Thermodynamics Conceptual Problems

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | David E Meltzer, Arizona State University

Additional Author | Chandralekha Singh, University of Pittsburgh

We use a validated conceptual survey instrument focusing on thermodynamic processes and the first and second laws of thermody-

namics as covered in introductory physics to investigate the context dependence of introductory and advanced student responses to introductory thermodynamics problems after instruction. The survey has conceptual problems that incorporate many contexts with the same underlying principles and concepts involving internal energy, work, heat transfer, and entropy. Here we focus exclusively on entropy. This study used data from over 1000 college students in introductory-level algebra- and calculus-based physics courses as well as upper-level thermodynamics courses. In addition to prior research, think-aloud interviews with a small subset of students in which they were asked to answer the survey problems while thinking-aloud was useful for understanding the context dependence of student responses in some situations. Here we present analysis of data in multiple contexts reflecting students' ideas about the change in entropy of a gas in spontaneous/irreversible processes and in cyclic processes. We find that a persistent belief in the constancy of entropy even for spontaneous/irreversible processes is a common difficulty among introductory students across problems with different contexts, while upper-level students had great difficulty across contexts in which identifying entropy as a state variable is important.

(MON-POS-N-PER504) | Poster Presentation Traditional | Challenges and Difficulties in collecting a truly representative sample of IPLS students for the FCE development

Presenting Author: Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | DJ Wagner, Grove City College

Additional Author | James Vesenka, university of New England

Additional Author | Daniel Young, University of Deleware

Additional Author | Dawn Meredith, University of New Hampshire

To increase the likelihood of developing a fair, reliable, and valid standardized research-based conceptual learning assessment instrument, researchers must use a truly representative sample of the types of individuals for whom the instrument is designed to evaluate. Researchers developing the Fluids Conceptual Evaluation (FCE) decided to make every attempt to establish a truly representative sample population of post-secondary IPLS students for every stage in development. This involved the collection of data from a variety of different types of institutions and students from around the country. Taking over three years to obtain, the researchers faced many challenges along the way. This poster presents an overview of these challenges and how the researchers collected the data for this development process as well as suggestions for future conceptual learning assessment developers. Supported by NSF Award #, 2021273.

(MON-POS-N-PER506) | Poster Presentation Traditional | Increasing Metacognitive Physics Problem Solving Skills: The Role of Self and Peer Grading

Presenting Author: Maria Dresser, Harvard University

Additional Author | Kelly Miller, Harvard University

Additional Author | Eric Mazur, Harvard University

This poster will present results of a cluster randomized control trial in an introductory electricity and magnetism course at Harvard University. Treatment group students completed self and peer grading of their weekly physics problem sets over the course of four weeks, while those in the control group did not complete any self or peer grading. Use of physics related metacognitive problem solving skills were assessed before and after the treatment using the Physics Metacognitive Inventory. The inventory is multidimensional and assesses six facets of metacognition in physics. Statistical modeling methods combining item response theory and regression analysis allowed for the investigation of treatment effects on each facet of metacognition measured by the inventory. Our findings show that students exposed to the self and peer grading treatment reported significant increases in their use of free body diagrams and their understanding of the utility of free body diagrams during physics problem solving.

(MON-POS-N-PER510) | Poster Presentation Traditional | The Fluids Conceptual Evaluation: Where Are We Now and Where Are We Going?

Presenting Author: Daniel Young, University of Delaware

Additional Author | James Vesenka, University of New England

Additional Author | DJ Wagner, Grove City College

Additional Author | Rebecca Lindell, Tiliadel STEM Education: Solutions for Higher Education

Additional Author | Dawn Meredith, University of New Hampshire

The development of the Fluids Conceptual Evaluation (FCE) involves a collaborative effort among multiple institutions to create a reliable, valid, and fair two-tier multiple-choice instrument covering both fluids statics and dynamics featuring multiple representations. We generated 66 Tier 1 conceptual items and gave subsets of these questions to students in think-aloud interviews. We are studying the reasons behind students' responses to generate Tier 2 responses for field testing. This poster presents an overview of the FCE and its various items along with our plans for future field testing with diverse student groups. If you are interested in participating in the FCE field test, please reach out to the project lead, Dawn Meredith, at dawn.merdith@unh.edu.
Project supported by NSF 2021273, 2021059, 2021261, and 2021224

(MON-POS-N-PER512) | Poster Presentation Traditional | Creating "Tier-2 Questions" for the Fluids Conceptual Evaluation

Presenting Author: DJ Wagner, Grove City College

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | James Vesenka, University of New England

Additional Author | Dan Young, University of Delaware

Additional Author | Dawn Meredith, University of New Hampshire

This work is part of a multi-institution collaboration developing the Fluids Conceptual Evaluation (FCE), a fair, valid, and reliable research-based conceptual fluids assessment for Introductory Physics for Life Science (IPLS) courses. The FCE will utilize two-tier multiple-choice items covering both fluid statics and dynamics. For each item, a Tier-1 question will ask for a factual answer, while the following Tier-2 question will ask the student to choose an explanation closest to their own reasoning. In 2021-2023 our group conducted 73 interviews at 10 diverse institutions, asking the students to answer a subset of our Tier-1 questions and to explain their reasoning. When coding those interviews, we identified student explanations that could serve as the basis for options in Tier-2 questions. This poster will describe the process of creating our Tier-2 questions and present several examples. IPLS instructors interested in serving as a field test site for the assessment should contact Project Lead Dawn Meredith.
Project supported by NSF 2021273, 2021059, 2021261, and 2021224.

(MON-POS-N-PER514) | Poster Presentation Traditional | Identifying Student Reasoning Difficulties in Analyzing Terminal Speed Behavior of Falling Objects

Presenting Author: Emily Moran, Western Washington University

Co-presenting Author | Ethan Dibeh, Western Washington University

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Noah Trostle, Western Washington University

At Western Washington University, research is underway to investigate student understanding of the terminal speed behavior of falling objects. We have developed a two-part written task involving three spheres, of varying size and mass, each falling at their own terminal speed. In part 1, students rank the spheres according to the drag force exerted on them. In part 2, students rank the spheres according to their terminal speeds. We've identified three core difficulties students face when analyzing terminal speed behavior: (1) low salience of the Fnet = 0 condition; (2) high salience of cross-sectional area as a determining factor; (3) difficulty analyzing cases where more than one variable is manipulated. In this poster presentation, we will discuss these core difficulties and others that arise in analyzing terminal speed behavior.

(MON-POS-N-PER516) | Poster Presentation Traditional | Assessment of Preservice Physics Teachers' Knowledge of Students' Understanding of Force and Motion

Presenting Author: LAN YANG, south china normal university

Additional Author | YANG XIAO, south china normal university

Co-presenting Author | LEI BAO, the ohio state university

In physics education, a number of studies have developed assessments of teachers' KSU of physics concepts with existing concept inventories, in which teachers were asked to predict the popular incorrect answers from students. The results provide useful but indirect information to make inference on teachers' knowledge of the misconceptions that students may be using in answering the questions. A new instrument is developed using a three-tier item design. The items were adapted from the Force Concept Inventory. Each item was designed in three tiers, with tier-1 asking for teachers' own answers to the question to test their content knowledge, tier-2 asking for teachers' predictions of popular students' answers, and tier-3 asking for teachers' explanations of students' incorrect answers in an open-ended form. The three-tier design captures teachers' content knowledge, predictions and explanations in a single item to allow explicit measures of teachers' own content knowledge and their KSU of students' misconceptions. The instrument was validated with preservice physics teachers. The assessment results also suggest that the preservice teachers' KSU on force motion was only moderately developed, and their content knowledge was uncorrelated with their KSU. In addition, a four-level progression scale of KSU was also developed, which categorized the preservice teachers into five proficiency groups.

(MON-POS-N-PER518) | Poster Presentation Traditional | Interdisciplinary Knowledge Integration for Connecting Physics and Chemistry Concepts in Student Learning of Galvanic Cell

Presenting Author: Lei Bao, The Ohio State University

Co-presenting Author | Dewei Ye, College of Education Zhejiang University

Additional Author | Lan Yang, The Ohio State University

The galvanic cell is a typical interdisciplinary topic, which is primarily taught in chemistry but its underpinning is in physics. Research on student learning in galvanic cell has revealed a large number of misconceptions that are difficult to change through traditional instruction in Chemistry. A source of the learning difficulties is that most students lack an explanatory framework to integrate the many complex phenomena and processes into a coherent knowledge system. As a result, students often rely on memorization of terms, laws, and equations in solving problems but without meaningful understanding. To address this issue, this study aims to help students understand the mechanisms in physics that can help explain the chemistry concepts and promote knowledge integration. Specifically, a conceptual framework model about galvanic cell is developed based on the central idea from physics, which is used as the core concept for mechanistic explanations of related chemistry concept. Guided by the conceptual framework, an instrument is developed to assess the knowledge integration in students' learning of galvanic cell. The results show that the conceptual framework model can effectively represent the knowledge structures of students at different levels of knowledge integration. Implications on developing effective instruction for promoting knowledge integration will also be discussed.

(MON-POS-N-PER520) | Poster Presentation Traditional | Validating a Measure of STEM Students' Self-Efficacy for a Mixed Methods Research Design

Presenting Author: John Byrd, Michigan State University

Additional Author | Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Self-efficacy, crucial for academic achievement in STEM, is typically assessed using pre-post measurements from surveys. However, developing a way to assess in-the-moment impacts to students' self-efficacy would create many opportunities for further study and intervention. With this goal, we devised a mixed-methods approach combining the Experience Sampling Method (ESM) with individualized daily journal prompts. While rich, this design poses validation challenges. To address these challenges, we analyzed three ESM survey questions, indicative of task-level self-efficacy, for skewness. Deviations from normal distributions suggest that traditional validation techniques may not apply. We further examined the Pearson's coefficient of skewness for each item and participant that does not assume the normal distribution of data. We would expect that if all ESM survey items are aligned with self-efficacy then the skewness for each individual should be consistent across those items. In this poster, we will present the shifts in skewness between items and discuss the data from validation interviews that expand on our quantitative findings.

MON-POS-N-PER520) | Poster Presentation Traditional | Instructors' Views on a Flexible Assessment Design

Presenting Author: Jesse Kruse, University of Colorado Boulder

Additional Author | Bethany Wilcox, University of Colorado Boulder

Flexible assessments are distinct from standard research-based assessments like the Force Concept Inventory in that the items and the item ordering may differ between administrations. Our group has been developing a flexible assessment for upper-level undergraduate quantum mechanics called the Quantum Physics Assessment (QuPA) to address the lack of consensus on what can/should be taught in an undergraduate quantum course. This assessment will exist on a web platform where instructors can select topics they want to assess and other testing parameters. In Fall 2023, we conducted 34 interviews with faculty

from institutions across the U.S. asking them about their experience with assessments, what they would improve, and what feedback would be useful. This paper will present the theory and motivation for flexible assessment of quantum mechanics proficiency, discuss our interview protocol, and summarize the general views of the instructors.

PER: Beyond Intro Posters II

(MON-POS-M-PER402) I Poster Presentation Traditional I Development, Validation and In-class Evaluation of an Interactive Tutorial on Mach-Zehnder Interferometer with Single Photons

Presenting Author: Chandralekha Singh, University of Pittsburgh

Additional Author | Emily Marshman, University of Pittsburgh

We developed and validated a Quantum Interactive Learning Tutorial (QuILT) on Mach-Zehnder Interferometer with single photons to expose upper-level students in quantum mechanics courses to contemporary applications. The QuILT strives to help students develop the ability to apply fundamental quantum principles to physical situations and explore differences between classical and quantum ideas. The QuILT adapts visualization tools to help students build physical intuition about quantum phenomena and focuses on helping them integrate qualitative and quantitative understandings. Findings will be presented from in-class implementation of the research-validated QuILT. We thank the National Science Foundation for support.

(MON-POS-M-PER404) I Poster Presentation Traditional I Development and Evaluation of a Quantum Interactive Learning Tutorial on Larmor Precession of Spin

Presenting Author: Chandralekha Singh, University of Pittsburgh

Additional Author | Benjamin Brown, University of Pittsburgh

We conducted research on student difficulties and used it as a guide to develop, validate and evaluate a quantum interactive learning tutorial (QuILT) on Larmor precession of spin to help students learn about time-dependence of expectation values in quantum mechanics. The QuILT builds on students' prior knowledge and strives to help them develop a good knowledge structure of relevant concepts. It adapts visualization tools to help students develop intuition about these topics and focuses on helping students integrate qualitative and quantitative understanding. Here, we summarize the development, validation and in-class evaluation. We thank the National Science Foundation for support.

(MON-POS-M-PER406) I Poster Presentation Traditional I Investigating and Improving Student Understanding of Quantum Mechanical Observables and Their Corresponding Operators in Dirac Notation

Presenting Author: Chandralekha Singh, University of Pittsburgh

Additional Author | Emily Marshman, University of Pittsburgh

In quantum mechanics, representations of quantum operators in the position or momentum representation is an important concept for students to learn. However, many students have difficulties writing operators in the position and momentum representations. We investigated student difficulties with quantum operators in the position or momentum representation in the context of Dirac notation so that we can use them to develop learning tools such as a Quantum Interactive Learning Tutorial (QuILT) to help students develop a robust understanding of these concepts. Here we describe the investigation of student difficulties. We thank the National Science Foundation for support.

(MON-POS-M-PER408) I Poster Presentation Traditional I Development and Validation of an Interactive Learning Tutorial on Quantum Key Distribution

Presenting Author: Chandralekha Singh, University of Pittsburgh

Additional Author | Seth Thomas, University of Pittsburgh

We describe the development, validation and in-class evaluation of a Quantum Interactive Learning Tutorial (QuILT) on quantum key distribution, a context which involves an exciting application of quantum mechanics. The protocol used in the QuILT uses single photons with non-orthogonal polarization states to generate a random shared key over a public channel for encrypting and decrypting information. The QuILT strives to help upper-level undergraduate students learn quantum mechanics using a simple two state system. It actively engages students in the learning process and helps them build links between the formalism and the conceptual aspects of quantum physics without compromising the technical content. The in-class evaluation suggests that the validated QuILT is helpful in improving students' understanding of relevant concepts. We thank the National Science Foundation for support.

(MON-POS-M-PER410) I Poster Presentation Traditional I Student Sense-making in Upper-level E&M in the Context of Problem-solving Involving Method of Images

Presenting Author: Jaya Shivangani Kashyap, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Instructors and researchers who focus on student sense-making try to understand 'how' students navigate the problem-solving process. Understanding these mechanisms plays an important role in helping students become good problem solvers. In particular, investigating student sense-making in the context of physics problem-solving can be useful for developing curricula and pedagogies to help students learn. We used individual interviews to investigate student sense-making in upper-level E&M in the context of problem-solving involving method of images as part of the development and validation of a research-based tutorial. Some of the interesting instances and findings will be presented.

(MON-POS-M-PER412) I Poster Presentation Traditional I Investigating a Problem-solving Theoretical Framework in Upper-division Electromagnetism Tutorials: Data from Focus Groups, Self-Assessments, and End-of-Semester Surveys

Presenting Author: Andrew Mason, Department of Physics and Astronomy, University of Central Arkansas

Additional Author | James Hecht, Department of Physics and Astronomy, Brigham Young University

Additional Author | Dorian Baldwin-Bott, Department of Physics and Astronomy, Brigham Young University

Additional Author | David W. Neilsen, Department of Physics and Astronomy, Brigham Young University

Additional Author | John S. Colton, Department of Physics and Astronomy, Brigham Young University

Research-based tutorials for upper-division undergraduate physics courses have typically either focused on one aspect of a problem-solving framework (e.g. mathematical methods) or on specific topics as opposed to more broadly across the course. Moreover, tutorials are often designed for the specific teaching environment of the host institution of the tutorials' creators. Currently we are investigating the effect of a sustained, semester-long system of tutorial development to address both the concerns of investigating a more thorough problem-solving framework at the upper-division level, and the effect of flexible tutorial design that is compatible with the instructor's course design and intended instructional methods. We investigate the effect of a set of tutorials designed in this way for a first-semester electromagnetism course at a large private Mountain West university during the Fall 2022 and Fall 2023 semesters; the Fall 2022 semester data consists of pilot study data for framing the design and data collection for the Fall 2023 semester. Data analyzed includes qualitative interview from student participant focus groups, and preliminary measurements of tutorial performance.

(MON-POS-M-PER414) | Poster Presentation Traditional | A Revised Edition of Tutorials in Physics: Quantum Mechanics

Presenting Author: Kristin Kellar, University of Washington

Additional Author | John Goldak, University of Washington

Additional Author | Peter Shaffer, University of Washington

The University of Washington Physics Education Group has been developing research-based curriculum for many years. Published editions of Tutorials in Physics have been used in university physics courses across the United States and internationally. As part of an on-going and large-scale project to produce updated editions of the Tutorials, we have developed new quantum mechanics tutorials for courses beyond the introductory year. We will also share materials for instructor support related to all of the quantum mechanics tutorials, such as instructor guides and a series of pre- and post-test items that could be used to measure improvements in student reasoning. This poster is a part of a series at this conference sharing the new materials available, and how interested instructors can connect and find support. This work is supported by the National Science Foundation, under grant No. DUE-1821032.

(MON-POS-M-PER416) | Poster Presentation Traditional | A Broader Methodological Perspective in Science Education

Presenting Author: Antti Rissanen, National Defence University

Additional Author | Kalle Saastamoinen, NDU, Filnland

Physics and mathematics are often categorised often as disciplines describing tools for technology. Instead of that student's skills develop while more courses are made, then physics may be taken even as a methodological discipline with qualitative sciences, combined with the formal language given by mathematics. Therefore methodology learning should be take into account in curriculum.. - One must be able to understand both mathematics and physics as a methodological, structuring tools for almos any substance questions. Also science is taught at several school levels and for a significant number of hours per week. But only a few students in high school aim to become subject teacher or researcher. Therefore learning goals are not mathematical and technical virtuosity linked to phenomena solving with math, but skills to form conceptual structure of the matter under investigation. Our presentation describes how we build our epistemological concepts for more motivating science education. The purpose is to discuss the theme in a poster session and update the overview of current research.

(MON-POS-M-PER418) | Poster Presentation Traditional | Evolution in Student Conceptual Understanding of Electricity and Magnetism

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | Alexandru Maries, University of Cincinnati

Additional Author | Chandralekha Singh, University of Pittsburgh

The Conceptual Survey of Electricity and Magnetism (CSEM) is a multiple-choice survey that contains a variety of electricity and magnetism concepts at the level of introductory physics used to help inform instructors of student mastery of those concepts. Prior studies suggest that many concepts on the survey are challenging for introductory physics students and the average student scores after traditional instruction are low. The research presented here compares the performance of students in introductory, upper-level, and graduate-level physics courses on five CSEM questions to understand the cross-sectional evolution of student understanding of these concepts from the introductory to upper-level to graduate-level. We discuss five CSEM questions that remain challenging for many upper-level and graduate students.

PER: DEI Posters II

(MON-POS-L-PER302) | Poster Presentation Traditional | Beyond Retention: The Design of a new Peer Mentor Program for Transfer Students

Presenting Author: Frank Dachille, Department of Physics and Astronomy, Michigan State University

Additional Author | David Tran, Michigan State University

Additional Author | Ashley Hewlett, Transfer Student Success Center, Michigan State University

Additional Author | Charles Jackson, Transfer Student Success Center, Michigan State University

Additional Author | Rachel Henderson, Department of Physics and Astronomy & CREATE for STEM Institute, Michigan State University

Additional Author | Vashti Sawtelle, Lyman Briggs College & Department of Physics and Astronomy, Michigan State University

We present the design and implementation of the Transfer Experience Mentoring Program (TEMPO) at Michigan State University (MSU), which launched in the Fall of 2023. TEMPO is designed to support transfer students through the transition between community colleges and MSU. At the national scale, students who first enroll at community colleges are historically undersupported, especially through the transition into the bachelor's granting institution. TEMPO utilizes resources from MSU to support a student's transition from their final semester of community college and into their first semester at MSU. TEMPO is supported by campus partners at MSU , and financially from the Howard Hughes Medical Institute Inclusive Excellence 3 project. In this presentation we will share how TEMPO represents a method of bridging the transfer transition gap between community college and a bachelor's granting university using peer mentoring, mentor training and resources sharing, and community building activities.

(MON-POS-L-PER304) | Poster Presentation Traditional | How Our Role as Instructors Shapes Women's Experiences in Undergraduate Physics Programs: A Comparative Analysis of Three Physics Departmental Cultures

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

This investigation compares the physics departments at three institutions using interview data from undergraduate women in physics. Using synergistic frameworks such as Standpoint Theory, Domains of Power, and the Holistic Ecosystem for Learning Physics in an Inclusive and Equitable Environment (HELPIEE), we analyze how those in the position of power, e.g., instructors, can play important roles in establishing and maintaining safe, equitable, and inclusive environments for students. This is especially important for historically marginalized students such as women and ethnic and racial minority students in physics. The three studies include Johnson's 2020 study using Domains of Power to investigate physics identity of students and faculty at a small predominantly White liberal arts college. The next study is Santana and Singh's 2023 study which utilized Standpoint Theory to understand the experiences of undergraduate women at a large predominantly White research institution and revealed a masculine physics culture. The third study is Santana and Singh's 2024 study which combined Standpoint Theory, Domains of Power, and HELPIEE frameworks to investigate undergraduate women's experiences at a small predominantly White private liberal arts college. This comparison is useful to understand the positive or negative qualities within these three departments which can help build a model for other departments to strive for.

(MON-POS-L-PER306) | Poster Presentation Traditional | Experiences of Linda, a Black Graduate Woman in Physics and Astronomy

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

We conducted semi-structured, empathetic interviews to understand their experiences in their undergraduate and graduate programs and how they navigate the physics departments at predominantly white institutions (PWI). The interviews serve as counter stories, which is a central tenet of Critical Race Theory. We use this framework to examine how racial identities play a role in the obstacles faced by these women, including interactions with peers and faculty members. We focus on the experiences of a Black woman in physics, Linda, to understand how her marginalized identities affected her experiences in physics during her undergraduate and graduate programs.

(MON-POS-L-PER308) | Poster Presentation Traditional | Examining the Role of Family in Women's Engagement and Success in Physics

Presenting Author: Laura Akesson, George Mason University

Additional Author | Jessica L Rosenberg, George Mason University

Additional Author | Nancy Holincheck, George Mason University

Additional Author | Benjamin W Dreyfus, George Mason University

Although some progress has been made over the last 50 years, physics still has one of the largest gender gaps of the sciences. The gap has been attributed to a variety of causes, including aspects of culture, early exposure to STEM, and gender-based psychologies, but few studies approach this issue centering the perspectives and experiences of women in physics. We focus on the role of family to understand the engagement and success of undergraduate women in physics. The poster presents our qualitative analysis of 120 surveys and 31 interviews of undergraduate physics students (92% identifying as female). We relate our findings to recent established STEM- and physics identity frameworks (including Carlone & Johnson and Hazari), and introduce new aspects emerging from our data.

(MON-POS-L-PER310) | Poster Presentation Traditional | Propelling Into Our Future

Presenting Author: Alícia López

Co-presenting Author | Edward Moriarty

Co-presenting Author | Joel Garcia

For years, the relationship between teachers and students has not evolved but stayed static. Teachers are seen as law-imposers and as the unique source of information, which is given to the students in a hurried and fast-paced way. Students sit, listen, and heave the previously heard information on a piece of paper during the exam. This buries the true and genuine spirit of education, which should be conducted with curiosity, motivation and their own interests in mind. In this poster, the new role of the teacher will be assessed, seen as a guide and a curiosity generator. Knowing this, and with the help of the MIT Edgerton Center, in Barcelona we've proposed a change. We started teaching our students based on hands-on projects and the implementation of team work, soft skills and analysis. Students focus all their effort into memorising concepts instead of understanding them and comprehending the consequences they have in the material world. Besides, students are not only allowed to fail, but also encouraged to do it. Failure is seen as another path towards learning, another tool for the student to grow and engage with their own education.
Sponsored by member Elizabeth Cavicchi

(MON-POS-L-PER312) | Poster Presentation Traditional | Students Attribute Myriad Cultural Factors to Their Sense of Physics

Presenting Author: Victor Marcos, South Seattle College

Co-presenting Author | Larissa Carter, South Seattle College

Additional Author | Andrea L. Wooley, Michigan State University

Additional Author | Chloe Elise Hennessy, South Seattle College

Additional Author | Abigail R. Daane, South Seattle College

When students describe physics, they often associate this science with facts, formulae, and objectivity. In our research, we asked students to reflect on how their own experiences influence their sense of the nature of physics. We analyzed two year college students' written reflections from introductory physics courses. Students described their own familial, cultural, and professional backgrounds, as well as their instructors' identities and teaching methods, as impacting their perspective of subjectivity and objectivity in physics. Although culture is often ignored in STEM classes, the students can benefit from recognizing the interplay between personal and societal structures within physics learning and practice. By making space in class to compare and contrast physics culture with students' own experiences, we hope to show students that their individual background is key to shaping their learning and improving the often inequitable field of physics.

(MON-POS-L-PER314) | Poster Presentation Traditional | Exploring Students' Perspectives on Femininity, Masculinity, and Androgyny within Introductory Physics Courses

Presenting Author: Yangqiuting Li, Oregon State University

Additional Author | Eric Burkholder, Auburn University

In this study, we adapted gradational measures from prior studies to investigate students' self-identified femininity, masculinity, and androgyny as well as their reflected appraisal of femininity, masculinity, and androgyny (i.e., perceptions of how others perceive them) in introductory physics courses. Our results show that the use of gradational measures revealed significant variation in students' self-identified femininity, masculinity, and androgyny within the binary categories of women and men and provided new insights of gender dynamics in physics. In particular, we found that many students in introductory physics courses perceive themselves as more masculine than how they think other people perceive them and self-identified women and students of color are more likely than self-identified men and White students to hold this perception. Using logistic regression and structural equation modeling, we found that students' gender stigma consciousness plays an important role in mediating the effects of identifying as women and students of color on the discrepancies between their self-identified and reflected appraisal of masculinity. Our findings underscore the potential of gradational gender measurements in deepening our understanding of gender related issues in physics education, shedding light on the complex interplay between students' gender identity, perceptions from others, and their educational experiences in the field.

PER: Intro Posters II

(MON-POS-K-PER202) | Poster Presentation Traditional | Great Questions Lead to Great Discoveries

Presenting Author: Michael Peterson, Triangle Math and Science Academy

Our physics textbooks are full of structured problems that teachers routinely practice with students in multi-step, guided explorations. However, in unstructured problems, students are given physical phenomena and are required to derive physics expressions and their logical consequences without the benefit of prompts. The assumption is that students will leap effortlessly from structured to unstructured problems on their own. This study (N=22) assessed the effects of structured and unstructured problems on students' physics understanding. In each unit, the instructor scaffolded student learning from structured problems to unstructured problems, and students were assessed on released Advanced Placement multiple-choice and free-response questions. Bayesian machine learning was used to determine the network of influencing factors.

(MON-POS-K-PER204) | Poster Presentation Traditional | Redesigning Legacy Conceptual Inventories: Validation Framework for 1-D Kinematic Items

Presenting Author: Brett Ballard, West Virginia University

In the ongoing effort to develop a new concept inventory of Newtonian mechanics, context neutral 1-D kinematic items were given to students at three universities. A validation framework for items is being developed which utilizes classical test theory, item response theory, differential item functioning, differential distractor functioning, exploratory factor analysis, and confirmatory factor analysis to provide a standardized way of quantitatively validating items in a concept inventory. Item difficulty and item discrimination from classical test theory are assessed using max item discrimination. Item point-biserial correlation coefficients and inter-item max phi correlation coefficients are calculated. Exam Kuder-Richardson Formula 20 with the item removed is compared with the full exam Kuder Richardson Formula 20. Item Response Curves are analyzed for various item response theory models. The Mantel-Haenszel Test is used for differential item functioning detection on these items. Additionally, exploratory factor analysis results are analyzed and theoretical factor models are tested using confirmatory factor analysis.

(MON-POS-K-PER206) | Poster Presentation Traditional | Next Generation Research-based Instructional Materials from the UW PEG

Presenting Author: Paula Heron, University of Washington

Additional Author | Peter S. Shaffer, University of Washington

Additional Author | Charlotte Zimmerman, University of Washington

The Physics Education Group at the University of Washington has been engaged in a long-term effort to improve student learning in undergraduate physics courses through research, curriculum development and support for instructors. Tutorials in Introductory Physics [1], a widely adopted set of materials developed for small-group instruction in calculus-based physics, is one result. The Tutorials have had a significant impact on teaching and research. However, the landscape in which the Tutorials were first developed is very different from that of today. As a result, the PEG has undertaken the development of a new set of flexible, modular materials that cover a wide range of topics, have a strong emphasis on reasoning, and are suitable for large lecture halls as well as small-group settings in introductory algebra-based and calculus-based courses, as well as in courses on quantum mechanics. In addition, we have developed resources and mechanisms to better support faculty, including online Instructor's Guides, collections of pre- and post-tests, and a pilot Faculty Online Learning Community intended to facilitate communication and collaboration among faculty using our materials at other institutions. This poster is a part of a series at this conference sharing the new materials available, and how interested instructors can connect and find support.

(MON-POS-K-PER208) | Poster Presentation Traditional | Leveraging Learning Assistants to Support STEM Identity

Presenting Author: Bradley McCoy, Azusa Pacific University

Additional Author | Elijah Roth, Azusa Pacific University

Additional Author | Karstin Dupont, Azusa Pacific University

Additional Author | Kaitlyn Fitzgerald, Azusa Pacific University

Previous research on physics identity by Hazari et al. has shown that interest, recognition, and performance are three key factors in students' development of a physics identity. Learning Assistants have potential to improve students' experiences in STEM classrooms by increasing performance and recognition. In this poster, we will present preliminary results from the STEM Identity (STEM-PIO-4) and STEM Career Interest surveys for courses supported by Learning Assistants in order to evaluate the impact of Learning Assistants on STEM identity.

(MON-POS-K-PER210) | Poster Presentation Traditional | Assessing Math Interventions in an Algebra-based Introductory Physics Course

Presenting Author: Cai Cash, University of Colorado Boulder

Additional Author | Eleanor R. Hodby, University of Colorado Boulder

Additional Author | Bethany R. Wilcox, University of Colorado Boulder

The foundational math skills covered in high school level math classes are essential for the development of strong physical intuition in introductory physics courses at the college level. Of these introductory courses, algebra-based courses often cater to a diverse group of students with backgrounds in math ranging from recent college courses to classes taken online during the COVID-19 pandemic. In this poster, we examine the impact of math preparation on student performance in an algebra-based introductory physics course at the University of Colorado Boulder, and analyze the effectiveness of current math interventions designed to bridge the gap between prior math skills and skills necessary for the class. We find that while math background plays a clear role in student performance in the class, the impact of current math interventions is a much more complicated story.

(MON-POS-K-PER212) | Poster Presentation Traditional | A Survey of Conceptual Modern Physics Courses in U.S. Colleges and Universities Intended for First-year Non-science Major

Presenting Author: Annie Courtemanche, Bemidji State University

Additional Author | Ryan T Sayer, Bemidji State University

In colleges and universities in the U.S., modern physics courses (i.e., courses focused on quantum mechanics, relativity, elementary particles and/or cosmology) are typically targeted for majors in physics or other STEM fields and usually require prior knowledge of classical physics and calculus. However, some colleges and universities also offer modern physics courses to first-year students who are not planning to major in STEM-related fields. These introductory modern physics courses generally receive less attention in the literature of PER. However, they present a unique opportunity to educate our future leaders and teachers about contemporary physics topics that often get overlooked in general introductory physics courses, giving them a deeper perspective of everyday technology and current physics research. In this study, we conducted an extensive review of the course catalogs of all four-year degree-granting U.S. institutions of higher learning and have compiled a list of modern physics courses targeted for non-science majors.

(MON-POS-K-PER214) | Poster Presentation Traditional | Characteristics of Women and Men Who Typically Worked Alone vs. Worked with Peers in Introductory Physics Courses

Presenting Author: Apekshya Ghimire, University of Pittsburgh

Additional Author | chandralekha singh, University of Pittsburgh

Meaningful collaboration with peers inside and outside the classroom can be an invaluable tool for helping students learn physics. We investigated the characteristics of women and men who most typically worked alone vs. those who typically worked with their peers in their algebra-based and calculus-based introductory physics courses when they took these courses before and during the COVID-19 pandemic. We will discuss these findings related to students' prior academic preparation, physics grade and self-efficacy as well as their perception of the effectiveness of working with peers on their physics self-efficacy.

TYC Posters II

(MON-POS-B-202) | Poster Presentation Traditional | The Organization for Physics at Two-Year Colleges: Where We Are and Where We're Going

Presenting Author: Kristine Lui, OPTYCs - AAPT

Additional Author | Dwain Desbien, Estrella Mountain CC

Additional Author | Rachel Ivie, AAPT

Additional Author | Sherry Savrda, OPTYCs - AAPT

The Organization for Physics at Two-Year Colleges, OPTYCs, is halfway into its 4-year grant-funded period. We present the goals of this project, highlight our accomplishments, and provide some hints towards post-grant sustainability. OPTYCs is sponsored by AAPT and funded by NSF grant #2212807.

(MON-POS-B-204) | Poster Presentation Traditional | Searching for Data on Two-Year College Physics: What We Found and What We Still Don't Know

Presenting Author: Sherry Savrda, AAPT-OPTYCs

As part of the OPTYCs project, we sought to learn as much as we could about two-year college physics programs. This search was made challenging by the fact that the last AIP survey of two-year college physics programs took place over a decade ago, and much of the information from other sources is conglomerated with other STEM programs or general undergraduate education data. In this presentation we will show some of what we were able to learn from across multiple data sets, and outline what we still hope to learn in the future. OPTYCs is supported by NSF-DUE-2212807.

(MON-POS-B-206) | Poster Presentation Traditional | Integrated Physical Science Course to Improve STEM Identity

Presenting Author: Jennifer Snyder, San Diego Mesa College

For many students their only experience with science is through courses that fulfill general education requirements whose purpose is primarily to increase science literacy. However, these courses can also have the benefit of introducing students to possibilities that they may not have considered in their educational careers. This is especially true for students who are under-represented in STEM fields. This project describes an Integrated Physical Science course whose purpose is to leverage student interest in problems in their own neighborhood in order to connect to the concepts. Key findings on student interest in the course and impacts on STEM identity will be shared.

(MON-POS-B-208) | Poster Presentation Traditional | Supporting New TYC Faculty with OPTYCs New Faculty Development Series– Cohort 2

Presenting Author: Krista Wood, University of Cincinnati Blue Ash

Additional Author | Brooke Haag, Pathstream

Additional Author | Dwain M Desbien, Estrella Mountain Community College   Additional Author | Tom O'Kuma, Lee College

The Organization for Physics at Two-Year Colleges (OPTYCs) and American Association of Physics Teachers (AAPT) present a 16-month experience designed specifically for Two-Year College (TYC) Physics Faculty in their first six years of TYC teaching. This New Faculty Development Series (NFDS) will support new TYC physics faculty incorporating student-centered active learning, and research-based instructional strategies. NFDS is an exceptional opportunity that provides new TYC Physics Faculty (1) a foundation in Physics Education Research (PER) with online discussions, (2) a 3-day Immersion Conference to engage in PER-based instructional and inclusive strategies, (3) online mentoring throughout the implementation phase, and (4) a 2-day Commencement Conference in conjunction with a National AAPT Conference. Cohort 2 will be Spring 2025 – Summer 2026. This NSF-funded program provides a community to support you and travel funding for the Immersion and Commencement Conferences! Supported by NSF-DUE-2212807

(MON-POS-B-210) | Poster Presentation Traditional | Increasing Student Engagement and Scientific Reasoning In Physics Courses

Presenting Author: Jonathan Pugmire, Snow College

Following participation in OPTYCs New Faculty Development Series Conference, I have implemented a range of enhancements to physics courses over the past year. This poster provides an overview of the strategies I've employed to foster a sense of community among students, enhance engagement and problem-solving skills through activities like whiteboarding sessions, TIPERs, and collaborative group tasks, and bolster students' capacity for scientific reasoning through hands-on laboratory experiences.

Session EA: Effective Practices in Educational Technology: Artificial Intelligence

Location: Harbor Level, Harbor I **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Kathryn McGill

(EA-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | AI in Physics Online Homework Platforms

Presenting Author: Jessica Moro, Pearson

Co-presenting Author | Rhone O'Hara, Pearson

Additional Author | Chris Hess, Pearson

In this presentation, we explore the transformative potential of generative Artificial Intelligence (AI) in revolutionizing educational landscapes, with a focus on physics. This transformation is achieved through personalized remediation and feedback mechanisms within online homework systems and while reading a textbook, offering a nuanced approach to cater to the individual learning needs of students. Generative AI introduces a dynamic method for addressing the varied learning challenges students face. It employs advanced machine learning algorithms to deeply analyze student responses. This allows the systems to pinpoint misconceptions and craft bespoke remediation strategies, providing real-time, personalized feedback as students tackle assessment questions. The application of generative AI in physics online homework systems ushers in a personalized learning journey. Here, students benefit from immediate feedback tailored to their specific learning paths. By identifying particular stumbling blocks and offering focused explanations and resources, these systems enable students to effectively address misunderstandings and solidify their grasp of fundamental concepts. However, employing generative AI for personalized remediation and feedback within physics online homework platforms requires a thoughtful examination of ethical and educational considerations. It's crucial to maintain transparency, accountability, and inclusiveness in these systems' design and operation, ensuring the mitigation of biases and the preservation of academic integrity.

(EA-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Integrating a Large Language Model AI-Chatbot into an Introductory Physics Lab

Presenting Author: Travis Kregear, Portland State University

Additional Author | Marina Babayeva, Portland State University

Additional Author | Ralf Widenhorn, Portland State University

At Portland State University, we have pioneered the integration of OpenAI's GPT-4 Large Language Module (LLM) into the introductory physics laboratory, serving as a virtual teaching assistant. The primary goal of this assistant is to provide immediate feedback and support to students as they work through the physics lab activities. Our approach involved analyzing transcripts of student interactions with the LLM during lab sessions. We evaluated the nature of student interactions with the chatbot and assessed the quality of the LLM's responses. Additionally, we conducted surveys to gather qualitative insights from students regarding their experience using the LLM assistant. This talk presents the key findings of our pilot study, including specific examples from the transcript analysis and student surveys.

(EA-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Student Use and Attitudes Towards ChatGPT in a Sophomore Lab

Presenting Author: Cory Christenson, Washington & Jefferson College

We gave students in a sophomore-level lab course free rein to use ChatGPT in whatever way they wished, to determine how, and what are effective ways, they might use it in such a setting. The course involved frequent report writing in Latex, and data analysis in Python, and is where physics-specific writing skills are primarily taught in the major. In general, students found it limited and reported it increasing the time it took to complete an assignment, but there were specific areas they found beneficial, such as writing code or thinking about sources of error. We will show transcripts of their conversations with ChatGPT and the results of a pre and post attitudes survey.

Session EB: PICUP: How Have You Integrated Computation into Your Classroom?

Location: Harbor Level, Harbor II **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Steve Spicklemire

(EB-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Computation as a Tool to Help Understand Uncertainty in Stopwatch Measurements

Presenting Author: Larry Engelhardt, Francis Marion University

One of the topics that we emphasize in introductory lab is how to compute and report uncertainties. For several years, we have started this topic with an activity that involves using a stopwatch to time an Arduino-controlled LED. Recently, this activity prompted a question that can be summarized as "Does it matter how many digits the stopwatch displays?" This question is best answered via computational experiments, which help us to better understand the relationship between the LED, the human (who is pushing the button), and the timer (which displays the measured values). In this talk, I will summarize the introductory lab experiment, and the subsequent computational experiments, and the significance of the results.

(EB-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Integrating Python Data Analysis in the Introductory Physics Laboratory Course

Presenting Author: Micol Alemani, University of Potsdam, Germany

Additional Author | Eugenio Tufino, University of Trento, Italy

Stefano Oss, University of Trento, Italy

The pace of data generation is increasing in all fields of experimental science and industry. Consequently, there is an increasing demand of people capable to analyse and interpret this data. Recognizing this need, we have shifted our focus already in the first year of the physics laboratory courses (PLCs) towards imparting 'computational skills' beyond traditional spreadsheet and scientific data analysis packages usage. In our presentation, we illustrate the implementation of Python-based data analysis using Jupyter-Notebooks at the University of Potsdam in Germany. The first year PLC already has many goals, thus we carefully integrated exercises and real-world physics scenarios to facilitate students learning Python fundamentals for data manipulation and analysis in an active way. Students apply subsequently these skills independently and collaboratively in the lab experiments. We assessed the effectiveness of our approach through qualitative empirical studies, which shed light on students' previous experiences in programming, expectations, and learning outcomes.

(EB-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Computation as a Tool to Investigate Realistic Situations in an Algebra-Based Introductory Physics via Spreadsheets

Presenting Author: Brokk Toggerson, University of Massachusetts-Amherst

Investigating realistic situations, such as situations involving air resistance, in algebra-based courses is often a great challenge. Most instructors either skip such topics or are forced to give a result derived with calculus with some justification, or sometimes with effectively no discussion at all. Skipping such topics can reinforce the common conception that "physics is not relevant to reality as it only explores contrived experiences that never happen in reality." Meanwhile, providing equations without being able to explore their origins could reinforce the conception that physics is, "a list of equations to be memorized." Computation permits a way around such challenges permitting the exploration of situations usually beyond the scope of introductory physics and even problems that lack analytical solutions. This talk will talk about how spreadsheets can be used as a computational framework along with some tips and tricks that the instructor has learned along the way.

(EB-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Computational Tutorial in Relativistic Motion with Constant Acceleration

Presenting Author: Duncan Carlsmith, University of Wisconsin-Madison

The general solution for relativistic motion subject to a constant force in three dimensions is presented and has a counter-intuitive feature: any transverse velocity is reduced to zero as is illustrated in a computational exercise for 1st year university physics students. Relativistic range and proper travel time are also investigated.

(EB-05 9:48 AM-10:00 AM) | Contributed Talk (12 Minutes) | Experiments and Modeling of Resistive Element Cooling via Forced Convection

Presenting Author: Blane Baker, William Jewell College

Experiments on cooling of a resistive element in a circuit have been conducted to determine temperature changes in moving versus still air. These data can be modeled effectively using equilibrium equations in which the electrical power input is balanced by radiative and forced convective cooling. Models predict temperature changes to within the uncertainty of temperature measurements. Data will be discussed, along with details of the experimental apparatus and computer modeling.

Session EC: Teaching the Introductory Physics for the Life Sciences (IPLS) Course

Location: Harbor Level, Harbor III **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Juan Burciaga

(EC-01 9:00 AM-9:24 AM) | | Medical Physics: Showing Undergraduate Students How to Apply Physics to Medicine

Presenting Author: Jennifer Pursley, Massachusetts General Hospital and Harvard Medical School

Medical physics is broadly defined as the application of physics to medicine. It uses physics concepts and advanced technology developed with the help of physicists to aid in the diagnosis and treatment of many diseases. For undergraduate students in physics and the life sciences, medical physics is a field they may not have heard of, but one where they can use their science skills to have real-world impact. In this talk, I'll cover many physics concepts that have led to medical advancements that can be used as examples of the applications of physics. I'll also discuss career opportunities in medical physics and pathways students can take to join the field of medical physics.

(EC-02 9:24 AM-9:48 AM) | | Developing Physical Modeling Skills in Introductory Physics for the Life Sciences

Presenting Author: Catherine Crouch, Swarthmore College

Additional Author | Benjamin Geller, Swarthmore College

Additional Author | Maya Tipton, Swarthmore College

Additional Author | Brandon Daniel-Morales, Swarthmore College

Additional Author | Nikhil Tignor, Swarthmore College

Additional Author | Rain White, Swarthmore College

Over the last fifteen years, many educators have developed and taught Introductory Physics for the Life Sciences (IPLS) courses. Such courses reimagine the year-long introductory physics course to optimize both content and skills for the interests and professional development of students pursuing the life sciences and health professions. I will present our approach to IPLS, highlighting commonalities with other approaches, and the results of one study examining how well it prepares students to model and analyze biological situations using physics. In that study, we assessed life science students' ability to carry out a sophisticated biological modeling task at the end of first-semester introductory physics. Some students were enrolled in a standard introductory course (N = 34), and some in an IPLS course (N = 61); both were taught with active learning, used calculus, and included the same core physics concepts. Compared to students who took the standard course, we found that the IPLS students were significantly more successful at building a model that combined ideas in a manner they had not previously seen, and at making complex decisions about how to apply an equation to a particular physical situation, although both groups displayed similar success at solving simpler problems.
Work supported by NSF under the IUSE program (EHR-1710875). Research results previously reported in Geller et al Phys. Rev. Phys. Educ. Res. 18, 010131 (2022).

Session ED: Makerspaces and Project Based Learning I

Location: Lobby Level - Marina Ballroom II **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Thomas O'Kuma

(ED-01 9:00 AM-9:24 AM) | | Transforming a Makerspace to Serve the College Community

Presenting Author: Dwain Desbien, Estrella Mountain Community College

When I took over as the faculty lead for The EMCC makerspace one of the first things I did was change our model and focus. Previously, the makerspace was more about making things for faculty, admin, staff and students rather than training those individuals to be makers. With this change in our model we had to address what are the appropriate tools and training for the space. This talk will focus on these changes and how the transformation has gone both in terms of physics but also to the broader college community.
Talk supported in part by the NSF funded OPTYCs grant, NSF #NSF-DUE-2212807

(ED-02 9:24 AM-9:48 AM) I I Challenges and Rewards of Incorporating a Makerspace in Your Classroom

Presenting Author: Anne Cox, Eckerd College

Many institutions have a Makerspace, but integrating them into our classrooms can be a challenge, even for physics teachers. A Makerspace takes a lot of care and feeding. This talk will focus on the examples of Maker-based projects that have worked and those that haven't and, importantly, the contexts for each. Scaffolding and strong connections to the classroom have been important for our success.

Session EE: PER: Student Reasoning I

Location: Lobby Level - Marina Ballroom III **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Ryan Sayer

(EE-01 9:00 AM-9:12 AM) I Contributed Talk (12 Minutes) I Supporting Student Reasoning in Physics Using Reasoning Chain Construction Tasks

Presenting Author: MacKenzie Stetzer, University of Maine

Additional Author | Thomas Fittswood, University of Maine

Additional Author | Beth A Lindsey, Penn State Greater Allegheny

A growing body of research has demonstrated that observed inconsistencies in reasoning on questions targeting the same physics concept may stem more from the nature of human reasoning itself than from specific conceptual difficulties. Analysis of student reasoning patterns through the lens of dual-process theories of reasoning (DPToR) suggests that students may struggle to engage analytical processing productively when responding to a physics question that contains salient distracting features. As part of a larger, ongoing effort to investigate and support student reasoning in physics, we have been exploring different strategies for using reasoning chain construction tasks to help students reason more productively. This talk will highlight recent results from our work on reasoning chain construction tasks and will also discuss implication for instruction and research-based curriculum development.

This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-2142416, DUE-2141975, DUE-2142276, DUE-2142436, DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

(EE-02 9:12 AM-9:24 AM) I Contributed Talk (12 Minutes) I Insight into Student Reasoning Using Online Reasoning Chain Construction Assessments (ORCCA)*

Presenting Author: Beth Lindsey, Penn State Greater Allegheny

Additional Author | Megan L. Nagel, Penn State Greater Allegheny

Additional Author | MacKenzie R. Stetzer, University of Maine

An emerging body of research has shown that, even after research-based instruction, students who demonstrate correct conceptual understanding and reasoning on one task often fail to use the same knowledge and skills on related tasks. This observation is particularly pronounced when a question contains perceptually obvious features that may distract from the appropriate reasoning pathway ("salient distracting features"). These observations can be accounted for by dual-process theories of reasoning (DPToR), which assert that human cognition relies on two thinking processes. The first, the heuristic process, is fast, intuitive, and automatic, while the second, the analytic process, is slow, effortful, and deliberate. In this talk, we will describe a multi-institutional interdisciplinary research project in which we are developing Online Reasoning Chain Construction Assessment (ORCCA) tools. These tools allow students to build an explanation for the answer to a question by selecting from a number of true statements about the task at hand. We will illustrate how these tasks can be used to better illuminate student reasoning and the role that salient distracting features of a task may play in disrupting normative reasoning pathways.

This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, DUE-1821561, DUE-2141975, DUE- 2142436, DUE- 2142416, and DUE- 2142276.

(EE-03 9:24 AM-9:36 AM) I Contributed Talk (12 Minutes) I Online Reasoning Chain Construction Tools to Probe Student Reasoning in Physics

Presenting Author: Mila Kryjevskaia, NDSU

Most science instructors will probably agree that one primary goal of our instruction is cultivating the ability to use formal knowledge to construct logically sound arguments. When students struggle to build such arguments, it can be easy to assume that they either do not possess the necessary content knowledge or their reasoning skills are weak. While these interpretations may be productive, dual-process theories of reasoning from cognitive psychology suggest that intuition is also a critical aspect of cognition. In fact, intuition is often powerful enough to significantly enhance or hinder explicit reasoning (even by those who hold correct formal knowledge). To probe the interplay between student formal knowledge, reasoning, and intuition, we designed and implemented Online reasoning chain construction tools, in which students are provided with correct reasoning elements (i.e., correct statements about the physical situation, relevant concepts, and mathematical relationships) and are asked to assemble them into an argument to answer a target question that often elicits incorrect intuitive responses. Data from calculus-based introductory physics courses will be presented, and implications for instruction will be discussed.

This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-2142436, 1821390, 1821123, 1821400, 1821511, and 1821561.

(EE-04 9:36 AM-9:48 AM) I Contributed Talk (12 Minutes) I Identifying Student Reasoning Trajectories via Metacognitive Reflection Tsks Informed by Dual-process Theories

Presenting Author: Em Sowles, University of Maine

Additional Author | Thomas Fittswood, University of Maine

Additional Author | MacKenzie R Stetzer, University of Maine

Students who have successfully applied relevant physics concepts and skills (mindware) to one physics question may perform inconsistently on an analogous question. These inconsistencies can be explained through dual-process theories of reasoning (DPToR). According to DPToR, there are a variety of ways in which both processes may be engaged and interact while students are thinking about the physics question, and this leads to many possible reasoning trajectories. While increased attention to these trajectories may help improve the effectiveness of instructional interventions, existing (large N) methodologies do not allow for the systematic identification and characterization of such trajectories. In this study, students were first given a screening-target pair of questions, with the screening question providing an independent measure of mindware and the target question focusing on the same physics concept, but often eliciting intuitive, incorrect responses. The question pair was then followed by a set of metacognitive prompts in which students were asked to reflect on their reasoning on the target question. This ongoing work explores how student reasoning trajectories may be impacted by differences in the target question (and the associated intuitive models generated by process 1). In this talk, we present recent results and discuss implications for instructional materials.

This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

Session EF: Teaching Quantum Mechanics to Promote Workforce Development III

Location: Lobby Level - Marina Ballroom IV **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** John Roeder

(EF-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Visualizing Complex Quantum States: Demonstrating Phasors

Presenting Author: Viva Horowitz, Hamilton College

Studying quantum physics requires comfort with imaginary numbers. Phasor demonstrations help build intuition in the complex plane. I will describe a rotisserie-style physical demo for visualizing a variety of wavefunctions, spanning complex waves in free space and bound wavefunctions, including eigenfunctions of the infinite square well. By visualizing the rotation of wavefunctions through complex space, students can better comprehend the relationship between wave behavior and energy states, enhancing their grasp of quantum physics.

(EF-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Nuclear Magnetic Resonance as an Entryway to the Quantum World

Presenting Author: Merideth Frey, Sarah Lawrence College

Additional Author | Colin Abernethy, Sarah Lawrence College

Additional Author | David Gosser, City College of New York

Co-presenting Author | Dedra Demaree, Blue Ridge School

As a crucial analytical tool in the modern STEM workforce, nuclear magnetic resonance (NMR) can provide a valuable entryway to quantum technology and research. This talk introduces a set of PER-influenced active-learning modules developed as part of an NSF-IUSE grant to make the quantum realm more accessible to students by integrating NMR across the undergraduate science curriculum. These modular labs were designed to cover the theory and applications of NMR with flexibility for use in a variety of different courses, classroom environments, and institutions. The developed materials take advantage of the growing capabilities of lower-cost benchtop NMR spectrometers available on the market but are also designed to be accessible for faculty and students who do not have direct access to a benchtop NMR spectrometer. This talk will provide an overview of the PER aspects of the modules, and how the modules have been refined based on evaluations conducted last year. Website with NMR modules for physics courses: https://sites.google.com/view/makingnmr/physics-modules

(EF-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Assessing and Revising Nuclear Magnetic Resonance Labs

Presenting Author: Dedra Demaree, Blue Ridge School

Co-presenting Author | Merideth Frey, Sarah Lawrence College

Additional Author | Colin Abernethy, Sarah Lawrence College

Additional Author | David Gosser, City College of New York

Multiple lab-based activities have been developed as part of an NSF-IUSE grant to help make NMR more accessible and integrate NMR into the undergraduate science curriculum. Many of these novel activities have been used in chemistry and physics classes over the past two years. These labs are strongly influenced by the Investigative Science Learning Environment (ISLE) philosophy, including observation and testing experiments. Therefore, we collected data similarly to what has been done in a few substantial ISLE-based projects. Video data allows us to consider types of engagement happening within student groups and survey data allows us to consider whether the activities are consistent with flow states for students. Findings from these and other assessments will be shared as evidence for the efficacy of these lab-based activities, as well as a discussion of how revisions based on first-year findings have improved achievement according to the target goals of the project. Website with NMR modules for physics courses: https://sites.google.com/view/makingnmr/physics-modules

Session EG: K-12 Instructional Innovations

Location: Harbor Level, Lewis **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Leila Madani

(EG-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Cultivating Active Engagement: Mystery Tubes

Presenting Author: Meghan DiBacco, Katy ISD - Cinco Ranch High School

Fostering an environment of active engagement and participation is paramount to unlocking the full potential of students. This presentation emphasizes the significance of cultivating a classroom culture that encourages students to become active participants in their own learning journey. Recognizing the pivotal role of the first day in setting the tone for the entire course, Mystery Tubes serve as a dynamic ice-breaking tool, seamlessly blending intrigue and exploration to captivate students' interest from the beginning. Through this experiential approach, students are invited to embark on a journey of discovery, sparking curiosity and igniting a passion for scientific inquiry. Furthermore, the use of Mystery Tubes fosters a culture of discourse and collaboration, as students engage in lively discussions to unravel the mysteries concealed within. This interactive process not only cultivates deeper conceptual understanding but also fosters a sense of community within the classroom.

(EG-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Momentum First, Projectiles Last

Presenting Author: Jason Sterlace, James Madison University

In an introductory physics course, student difficulty is predictable in specific topics such as vectors, accelerated motion, and especially 2D accelerated motion like projectiles. The traditional order of topics imposes a heavy cognitive load on novices, discouraging and alienating many. The course's order of topics can influence whether students succeed, or founder, or just drop the course. In this talk, I describe a lab-first, guided inquiry course that begins with momentum, proceeds to forces, then energy, and places acceleration late in the mechanics sequence. Further, by presenting 2D and 3D topics after students have spent time with Newtonian concepts, student apprehension and confusion are reduced. This course described is one I have taught in high school physics classrooms, including 9th grade Physics First.

(EG-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Rechargeable Battery Made Out of Play-Doh

Presenting Author: Martin Vysohlid, North Warren Central School

Students often think of “error of experiment” when the result does not agree with their expectation. However, in real physics, disagreement of experiment with our expectation is the fuel that powers new discoveries. In this presentation, I want to share my experience with high school students where we found more physics in simple labs, and ultimatelly they noticed an effect that lead to discovery and design of a Play-Doh rechargaeble battery in our classroom.

(EG-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Energy and Equity in High School Physics Instruction

Presenting Author: W. Tali Hairston, Equitable Development LLC

Co-presenting Author | Heena Lakhani, University of Washington

Energy learning frames and pedagogical practices that integrate social contexts may allow high school teachers to address inequities in the sustainable and just use of energy resources. In this talk, researchers and high school teachers will share learnings from their energy and equity professional learning community. We will discuss the impact of teaching socio-politically relevant energy and equity, relevant struggles in adopting an energy and equity learning framework, and the pedagogical challenges in bridging conservation models to social justice perspectives. We will also invite participants to reflect on a framework for integrating energy and equity in high school physics instruction[1]. While addressing access and achievement the framework includes an analysis of power structures and justice approaches to equity in supporting high school physics teachers to integrate equity and justice into their energy teaching and learning.

(1) Scherr, R., Huynh, T., Hairston, W., & Gray, K. (2023). A Framework for Integrating Energy and Equity in High School Physics Instruction. The Physics Teacher, 61, 606–610. https://doi.org/10.1119/5.0134319

Session EH: PER: Intro

Location: Mezzanine Level - Douglass **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Jonathan Perry

(EH-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Utilizing Collaborative Reading to Facilitate Learning in Introductory Physics

Presenting Author: Jessica Bickel, Cleveland State University

Few students read the textbook. This work examines collaborative reading at a public urban university. In collaborative reading students are assessed by their engagement with the text through writing comments, asking questions, and replying to their classmates. The instructor can use these in a JiTT fashion to focus the classroom discussion and learning. This study covers multiple sections of calculus-based introductory physics led by four faculty members. Student survey data shows that the students are more likely to read with collaborative reading compared to traditional reading with questions in agreement with a study at a ivy-league university. This is likely due to enforcement as students say they would not be as likely to read if it was just assigned. This study will further examine when student habits are set, differences between 1x and 2x per week assignments, and how the reading correlates to student learning through grades and concept assessments.

(EH-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Impact of Open-Access Supplemental Materials in an Introductory E&M Course

Presenting Author: James Hirons, Texas A&M University

Additional Author | Dawson T. Nodurft, Texas A&M University

Additional Author | Jonathan D. Perry, The University of Texas at Austin

Additional Author | Tatiana L. Erukhimova, Texas A&M University

Performance in introductory courses, particularly physics, are often crucial for student success in STEM majors and can impact an individual’s tendency to persist in their chosen field. To provide students with quality resources and enhance their individual learning experiences, faculty at many universities across the country have worked to develop open-access materials to help students build conceptual understandings and problem-solving skills. This work seeks to explore and measure the potential impact that these resources have on student success in an introductory, calculus-based electromagnetism course. Data were collected from two fall semesters, 2021-2022, including classroom performance, a conceptual assessment, and relevant university level data to contextualize student background and pre-class abilities. We will present results from regression analysis and discuss how the use of supplemental materials appears to impact students’ performance and improvement in the course.

EH-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | A Highly Accurate Way to Predict Which Students Will Pass (C or better) a Conceptual-focused Algebra-based First-semester Physics Class with Moderately High DFW Rate

Presenting Author: Robert Cohen, East Stroudsburg University of Pennsylvania

With a 40% DFW rate in the intro physics class, it was striking how success (C or better) was entirely predicted by number sense and GPA. In particularly, all of the students who scored <50% on an in-house survey and <3.2 GPA (prior to taking the class) failed to get at least a C in the class, whereas everyone else received at least a C in the class. I’ll discuss what number sense means, how we assess it, why it is crucial for conceptual understanding in a quantitative course, and implications for secondary and college math and science education.

(EH-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Should Speed be a Valued Instructional Goal in Physics Courses?

Presenting Author: Harish Moni Prakash, The Ohio State University

Additional Author | Andrew F Heckler, The Ohio State University

In introductory undergraduate Physics courses, we explore the relevance of a student’s speed on basic STEM skills like algebra, trigonometry, and vectors. We have found that among students with the same accuracy level on basic STEM skills, faster students are likely to get better course grades. We question whether this speed-grade relation is because speed is necessarily useful for Physics learning, or if it is a product of timed assessments like exams and quizzes. To answer this question, we hypothesize models of speed-grade relations based on empirical evidence and using mechanisms studied in cognitive psychology. From an instructional perspective, these models help understand whether speed should be valued and rewarded in Physics courses as a relevant and useful cognitive ability, or if rewarding speed can be biased against students who are slower on assessments. We propose tests for these models and plan to explore whether the observed speed-accuracy-grade relations are causal.

This research was primarily supported by an NSF IUSE grant, award 1914709.

(EH-05 9:48 AM-10:00 AM) | Contributed Talk (12 Minutes) | Using Socially Mediated Metacognition to Understand the Behavior of Introductory Laboratory Groups

Presenting Author: Katie Ansell, University of Illinois Urbana-Champaign

Additional Author | Caitlin Mamaril, University of Illinois Urbana-Champaign

Additional Author | Hamideh Talafian, University of Illinois Urbana-Champaign

When student groups navigate through a minimally-guided introductory physics laboratory task, the way they proceed through the experiment and assignment can vary significantly. For established groups that seem highly organized and cohesive, a closer look at key transition points in the experimental process reveals a spectrum of interactions that range from chaotic, to fluently complex, to sparse and linear. We propose that the types of episodes that groups enter during key transitions is linked to the socially mediated metacognitive roles students take on within the group – that is, how individuals prompt the group toward experiment quality and/or task completion. We have explored this mechanism with recordings of introductory calculus-based Mechanics students completing an end-of-semester lab practical task. Our talk presents results using these video data to theorize this metacognition-complexity connection and apply it as a characterizing framework for differing behaviors of groups in introductory physics laboratories.

Session EI: TYC: Initiatives Across Institutions

Location: Grand Ballroom D **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Stock Weinstock-Collins

(EI-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Status Report on The Organization for Physics at Two-Year Colleges

Presenting Author: Kristine Lui, OPTYCs - AAPT

Additional Author | Sherry Savrda, OPTYCs - AAPT

Additional Author | Rachel Ivie, AAPT

Additional Author | Dwain Desbien, Estrella Mountain CC

Join us in celebrating OPTYCs 2nd birthday! The Organization for Physics at Two-Year Colleges, OPTYCs, is halfway into its 4-year grant-funded period. In this talk, we outline the goals of this project and showcase our accomplishments thus far. OPTYCs is sponsored by AAPT and funded by NSF grant #2212807.

(EI-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | What Do We Really Know About Two-year College Physics Programs?

Presenting Author: Sherry Savrda, AAPT-OPTYCs

Current data suggests that roughly 50% of the students taking introductory physics in the US are taking those courses at a two-year college. But what do we really know about those students and the impacts of two-year colleges on STEM education in general? The last AIP survey of TYC physics programs was undertaken over a decade ago. As a result, finding information about TYCs in general and TYC physics in particular requires a deep dive into multiple sources of data, much of which is outdated. This presentation will review some of the available data, point out some of the limitations in the data, and describe efforts to improve our understanding of two-year college physics programs.

(EI-03 9:24 AM-9:36 AM) | Contributed Talk (12 Minutes) | Transfer Advocacy Groups: A Proposed Tool for Institutional Change

Presenting Author: Vashti Sawtelle, Michigan State University

Additional Author | Annie Chase, San Jose State University

Additional Author | Missy D. Cosby, University of Tennessee, Knoxville

Additional Author | Angela Little, Angela Little LLC

Additional Author | Camila Monsalve Avendaño, Michigan State University

Additional Author | Gina Quan, San Jose State University

Over the past decade nearly half of all post-secondary students of color have attended community colleges. This presentation shares an overview of a new project that aims to address the need to support community college transfer students of color in science, technology, engineering, and mathematics (STEM) fields by transforming the receiving baccalaureate granting institutions. This NSF-funded project is a collaboration of two institutions, San Jose State University and Michigan State University. We have created Transfer Advocacy Groups (TAGs) which are collaborations of faculty, students, and advisors working to implement interventions to support transfer students of color in STEM and promote a transfer receptive culture at the receiving baccalaureate granting institutions. In this presentation we will share an overview of this project and its intended goals for impacting change at the baccalaureate granting institutions. Our goal with this presentation is to invite feedback from the two-year college in physics community on our process and goals with the TAGs.
This work is supported by NSF Award #2224295

(EI-04 9:36 AM-9:48 AM) | Contributed Talk (12 Minutes) | Level Up Your Leadership: The TYC Leadership Institute

Presenting Author: Brooke Haag

Additional Author | Dwain Desbien , Estrella Mountain Community College

Additional Author | Krista Wood, University of Cincinnati -- Blue Ash College

Additional Author | Tom O'Kuma, Lee College -- Retired

The Leadership Institute under the Organization for Physics at Two-Year Colleges and AAPT is a fellowship for two-year college physics faculty to help participants develop and apply leadership skills. Under the guidance of a team of TYC mentors, you will cover topics including effective communication, work-life balance, finding leadership strengths, understanding the national context for science education, framing challenges, leading change, and valuing diversity. You will have the chance to construct and implement an action plan to address a challenge or opportunity in your work. In this talk we'll discuss past iterations of the Leadership Institute as well as future plans for the next iteration of the program. (Supported by NSF-DUE-2212807.)

(EI-05 9:48 AM-10:00 AM) | Contributed Talk (12 Minutes) | Preparing Community College Students for STEM Career Pathways thTrough Mentoring

Presenting Author: Anne Leak, Center for Science and Engineering Partnerships at UCSB

Additional Author | Lubella A Lenaburg, Center for Science and Engineering Partnerships at UCSB

Additional Author | Jyllian Herman, Center for Science and Engineering Partnerships at UCSB

Community college physics classes are more reflective of the diversity in their communities than four-year universities while also providing students with a launch-point for a variety of physics and engineering careers. However, in order to be successful in STEM careers and transfer into further physics and engineering degree programs, students in these courses require additional support and benefit from strategic mentoring and advising. After examining over 10 years of NSF S-STEM program evaluation reports including survey and interview data for 248 community college students, we have identified several successful attributes and approaches of mentors that have supported students on their education and career paths. Our findings include insights into how the roles of advisors, faculty mentors, peer mentors, and communities can be strengthened to promote long term education and career success for students who need it most while improving the diversity of physics and engineering fields.

Session EJ: PhysTEC: Media Hype & Physics Teaching

Location: Grand Ballroom C **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Adam LaMee

EJ-01 9:00 AM-9:48 AM) | | How Media Hype Affects Our Physics Teaching: What 21st Century Educators Need to Know

Presenting Author: Josephine Meyer, University of Colorado Boulder + Quantum Ethics Project

Additional Author | Gina Passante, California State University Fullerton

Additional Author | Steven J Pollock, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Popular media is an ever-present, if seldom discussed, element of the broader landscape in which our students are learning and a tool we can use productively in our teaching (Meyer et al. 2023). And of course, we can't talk about popular media without talking about hype. Media hype can be a double-edged sword for us as educators, being both a motivator and a source of inflated and inaccurate preconceptions that we must help students "unlearn" in our classrooms. After a brief module on the social science of media hype, we will learn and apply research-inspired tools to understand the impact of media hype on our students' learning and how we can adapt our instruction accordingly. Attendees are asked to bring one example of a topic in their course receiving significant media coverage (whether in sci-fi, popular science, or news) that we will analyze together in an interactive activity.

J.C. Meyer, G. Passante, S.J. Pollock, and B.R. Wilcox. "How media hype affects our physics teaching: A case study on quantum computing." Phys. Teach. 61(5), 339-342 (2023).

Session EK: What Would You Do Different?

Location: Concourse Level - Commonwealth B **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Toni Sauncy

Looking back on your past/current physics teaching experience/experiences what would you do differently.

Session EL: Graduate Teacher Education Programs

Location: Grand Ballroom E **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Douglas Petkie

EL-01 9:00 AM-9:24 AM) | | STEMteach: Lessons from a One-year Post-bacc Teacher Preparation Program

Presenting Author: Earl Blodgett, University of Wisconsin-River Falls

Co-presenting Author | Rachelle D Haroldson, University of Wisconsin-River Falls

STEMteach is a one-year initial licensure post baccalaureate graduate program inspired by UTeach and funded by multiple NSF grants. The program is designed for STEM degree holders, either career changers or late deciders; thus, the focus of the program is on learning effective STEM pedagogy, not STEM content. This teacher preparation in STEM pedagogy follows a spiraled approach incorporating early and often field experiences with progressively older student audiences, building confidence in assessment, culturally relevant pedagogy, and instruction and integrating STEM across the curriculum. In this session we will highlight the value in having a cohort of multiple STEM disciplines working together and learning from each other. Pragmatically, a multi-disciplinary program also increases enrollment and thus enhances financial viability. We will share takeaways from our experience with seven cohorts of graduate students that led to 53 licensed teachers, of which at least 44 are persisting in education careers. We will discuss lessons learned regarding the crucial role of a Master Teacher or mentor having close regular contact with the cohort, whether through teaching, advising, or supervising.

STEMteach was created under a Noyce Capacity Building Grant 1439768 and further supported by a Noyce Track I Stipend Grant 1660135.

(EL-02 9:24 AM-9:48 AM) | | Supporting Secondary Physics Teachers Through an Online Physics Master's Program

Presenting Author: Robynne Lock, Texas A&M University-Commerce

Additional Author | William G Newton, Texas A&M University-Commerce

There is a severe shortage of high school physics teachers, and of those teaching physics, only about one-third have a degree in physics or physics education. This creates a need for programs that support teachers in improving their content knowledge. Furthermore, the demand for dual credit courses is increasing, and many high school teachers seek to earn the necessary credentials to be able to teach up to the community college level. To address these needs, Texas A&M University-Commerce has created a Master's in Physics with Teaching Emphasis program. The program is fully online and asynchronous in order to accommodate teachers' schedules. Each of the program's core courses covers a content area such as Classical Mechanics or Electricity and Magnetism. In addition to the expected problem sets, the courses incorporate content-specific physics education research, the history of the field, and modern applications of the content.

Session EM: Hands on with the Physics of Video Games

Location: Concourse Level - Commonwealth A **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Chris Orban

(EM-01 9:00 AM-9:48 AM) | | Hands on with the Physics of Video Games

Presenting Author: Chris Orban, Ohio State University / STEMcoding Project

This session is a mini version of our half-day workshop where we will focus on a few "physics of video games" NGSS-aligned activities which are designed for 9th grade physical science, but can be used even at the intro college level. We will focus on a few javascript based activities like the classic asteroids game, angry birds and Pong. Many of these activities can automatically give the student a check or a little red x depending on whether they completed a task successfully. These activities are part of the STEMcoding project which has an excellent youtube channel (http://youtube.com/STEMcoding) which frequently features women and underrepresented groups in STEM.

Session EN: PER: Faculty Development Strategies

Location: Lobby Level, Stone **Time:** 9–10 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** DJ Wagner

(EN-01 9:00 AM-9:12 AM) | Contributed Talk (12 Minutes) | Validation of the Student Inclusive Teaching Strategies Inventory (ITSI-S) for instructional STEM laboratory settings

Presenting Author: Julia Willison, University of Central Florida

Additional Author | Ramses Rojas, University of Central Florida

Additional Author | Kathleen Lugo, University of Central Florida

Additional Author | Erin M. Scanlon, University of Connecticut - Avery Point

Additional Author | Erin K. H. Saitta, University of Central Florida

Additional Author | Jaquelyn J. Chini, University of Central Florida

Access and inclusivity in instructional laboratory settings is an important topic in our modern age. Student perceptions of inclusivity are paramount for understanding access needs in classroom settings. The Inclusive Teaching Strategies Inventory - Student (ITSI-S) is an instrument for measuring students' perceptions of the inclusivity of various classroom practices. The instructor component, the ITSI, has been validated for STEM classrooms and for laboratory instructors and significant changes were made by our study team members in previous years. In this presentation, we cover our validation of the ITSI-S. Data were collected through interviews with students in laboratory courses. Then, we utilized content analysis to uncover areas where students misunderstood the question or needed further clarification. The ITSI-S could be a valuable tool to help investigate inclusivity in labs from the student perspective, and could in particular give voice to disabled students.

(EN-02 9:12 AM-9:24 AM) | Contributed Talk (12 Minutes) | Exploring Shared & Adjacent Experiences in Fostering Empathy in Physics Faculty

Presenting Author: Alia Hamdan, Rochester Institute of Technology

Additional Author | Ash Bista, Rochester Institute of Technology

Additional Author | Scott Franklin, Rochester Institute of Technology

Additional Author | Dina Newman, Rochester Institute of Technology

Empathy, the ability to intellectually and/or emotionally understand another person's thoughts and feelings, is instrumental to developing a safe and inclusive learning space and departmental culture. We explore physics faculty's utilization of shared and adjacent lived experiences in the development of empathy towards students and colleagues. We apply emergent thematic analysis to semi-structured, longitudinal interviews of nineteen physics faculty. We find differences in the pace of empathy development that depend on the experiences and personal toll of empathizing. Shared lived experiences, firsthand identical events shared by faculty and students, facilitate quicker emotional recall and emotional empathy development but entail a higher mental toll. Conversely, adjacent experiences, events that might trigger similar emotions but differ in nature, can enhance cognitive empathy but necessitate intentional exploration of others' mental states. This research sheds light on faculty's engagement with their role as agents of change.

This research was sponsored through NSF Award #2222337

STEP UP

PHYSICS TOGETHER

STEP UP is a national community of physics teachers, researchers, and professional societies. We design high school physics lessons to empower teachers, create cultural change, and inspire young women to pursue physics in college.

If half of the high school physics teachers encourage just one more female student to pursue physics as a major, a historic shift will be initiated — female students will make up 50% of incoming physics majors.

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STEPUPphysics.org

Session FA: Advanced Lab Design: Reflections and Suggestions

Location: Harbor Level, Harbor I **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Catherine Herne

(FA-01 10:00 AM-10:24 AM) | | Opportunities and Challenges of Incorporating Quantum Experiments into Advanced Lab Courses

Presenting Author: Victoria Borish, University of Colorado Boulder and JILA

Additional Author | Heather J Lewandowski, University of Colorado Boulder and JILA

Advanced lab courses are often the only place in the undergraduate physics curriculum where students are able to work with experiments requiring both complex apparatus and a conceptual understanding of topics extending beyond what is taught in standard theory courses. Included in this are various types of quantum experiments, which many instructors are currently considering in part due to their increasing prevalence in both industry and academia. Quantum experiments may provide unique opportunities for students, such as helping them learn about topics and techniques in modern research labs, become more motivated to pursue physics, and better understand the connection between theory and experiments. These complicated experiments also come with challenges, such as figuring out the optimal amount of structure so students can get to the data collection and analysis stages while still making some of their own decisions. Additionally, educators need to think about how to provide these experiences to students at institutions with any level of resources. In this talk, I will discuss challenges and opportunities for the incorporation into advanced lab courses of two types of quantum experiments: hands-on quantum optics experiments and an ultracold atomic physics experiment accessible online.

(FA-02 10:24 AM-10:48 AM) | | Labs Are Fun! Implementing Authentic Experimental Practices in the Advanced Laboratory to Improve Professional Development and Spark Joy

Presenting Author: Sara Mueller, Brown University

Instructional labs can feel like a grind for students and instructors. At the same time, many of us know the excitement that comes from experimental physics work. How do we connect to the joy of research in the labs when we are in a contrived situation like the instructional lab? In this talk, I will describe some authetic practices I have implemented in an upper division instructional lab. We transitioned away from lab reports towards weekly slide-deck updates like you might experience in a research group. Students collaborate across the semester and train each other on experiments. At the end of the term we have a professional-society style meeting with a talk and poster session. From the course feedback and conversations with previous students, it is clear that while this approach hasn't eliminated the time-sensitive stressors of completing experiments in a few weeks, it has provided opportunities for students to behave as working physicists.

Session FB: PICUP: Integrating Computation into Undergraduate Physics

Location: Harbor Level, Harbor II **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Steve Spicklemire

(FB-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Linking ComPADRE with Web EJS and Tracker Online

Presenting Author: Wolfgang Christian, Davidson College

The AAPT ComPADRE OSP digital library offers hundreds of ready-to-run simulations and video experiments made with our authoring tools - EJS and Tracker. These Java-based desktop applications run on OS X, Windows, and Unix computers. However, some schools no longer permit Java on their computers, and Java is not supported on mobile devices. The OSP team has developed browser-based versions of EJS and Tracker using JavaScript to address these issues. Additionally, we have added links to ComPADRE that load OSP source code and videos directly into our browser-based authoring tools. This feature enables teachers and students to quickly explore and modify the original OSP material. Examples of this feature will be presented.

(FB-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Norwegian Teachers' Views of Programming in Physics and General Science

Presenting Author: Henning Myhrehagen, University of Oslo, Center for Computing in Science Education

Additional Author | Tor O. B. Odden, University of Oslo, Center for Computing in Science Education

Additional Author | Ellen K. Henriksen, University of Oslo, Research Section for Physics Education

Norway has recently implemented new science curriculum standards which explicitly include scientific programming. However, the curriculum documents do not provide clear-cut guidelines on how and to what extent programming should be used for science learning. To understand the effects of the new curriculum, we have surveyed Norwegian high school science teachers to find out what affordances they see with the use of programming, and what challenges they are experiencing. Our results show that most teachers in general science and physics have started using programming in their classrooms, although their perceived programming proficiency and confidence varies greatly. Physics teachers regard programming as a useful tool that enables the students to learn more physics than what was possible without programming. Teachers of other science subjects struggle to see how and why programming should be integrated with their subject. Based on these results, we argue that teachers need continued support from teacher educators and researchers from the science disciplines to advance the disciplinary integration of programming. We suggest that the overlap between scientific practices and computational thinking practices should play a central role in these efforts.

(FB-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | A Project Centered Computational Physics Course Using Python

Presenting Author: David Jackson`, Dickinson College

Computational physics can be integrated into the physics curriculum in many different ways. In this talk I will discuss a junior-level computational physics course that focuses on projects of increasing complexity. This one-semester course assumes no prior programming experience and is designed around four projects: (1) curve fitting (including measurement uncertainties), (2) integral functions and data reduction, (3) the damped, driven pendulum and chaotic motion, and (4) an independent project chosen by the student. In addition to providing an overview of these projects, I will give an outline of the material presented in preparation for each project. Finally, I will share my thoughts and experiences having now taught this course four times over the past eight years.

(FB-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | How Five Years of Computational Instruction Changes Physics Students' Identity and Programming

Presenting Author: Karl Henrik Fredly, University of Oslo, Norway

Additional Author | Tor Ole Odden, University of Oslo, Norway

Physics students at the University of Oslo learn programming from day one, and many of them continue learning and using programming throughout their studies, with programming being incorporated into nearly every physics course. How does this affect their view of themselves as physicists? And what kinds of programming competence do physics students gain from five years of computational physics experience? To answer these questions, we have interviewed Computational Physics masters students and analyzed their masters theses. This analysis reveals that over their physics careers, these students develop an efficient and pragmatic coding strategy, hold a specific epistemology of computational physics, and built these competencies and views through pivotal social and educational interactions. In this talk, I will describe these contributing factors and student outcomes, and discuss how these findings can be applied to improve the teaching of computational physics.

Session FC: IPLS Poster Roundtable

Location: Harbor Level, Harbor III **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Juan Burciaga

(FC-01) | Poster Presentation Traditional | Computation in the IPLS course

Presenting Author: Peter Nelson, Fisk University

A new approach to the IPLS course is presented. Instead of kinematics, we start with diffusion because students already appreciate its central role from high school biology. Students start by playing the "Marble Game" with a ten-sided dice determining jumps of ten marbles between two boxes. Implementing it in Excel, they discover Fick's law of diffusion. Finite difference methods are then developed to predict and understand the Marble Game's ensemble-average behavior. Students then apply similar techniques to drug elimination, radioactive decay, osmosis, ligand binding, enzyme kinetics, the Boltzmann factor, entropy, phase equilibrium, random walks, membrane voltage, and the action potential to discover the consequences of model assumptions. Students validate their models by comparison with data from foundational experiments. Students thus discover for themselves that science is an evidence-based endeavor with testable hypotheses that are supported by experiment using authentic life-science applications of Physics.

(FC-02) | Poster Presentation Traditional | Changes in Physics Affinity from Introductory Physics for Life Sciences at Three Institutions

Presenting Author: Nikhil Tignor, Swarthmore College

Additional Author | Drake Roth, Swarthmore College

Additional Author | Lundy Zheng, Swarthmore College

Additional Author | Lili Cui, University of Maryland Baltimore County

Additional Author | Dan Young, University of Delaware

Additional Author | Catherine H. Crouch, Swarthmore College

Recently, a national effort has focused on improving introductory physics for the life sciences (IPLS), both to optimize the content and skills taught and to support growth of interest and appreciation of the value of physics for the life sciences. We previously found that after such a course at one institution, student self-reported interest in physics and perception of relevance of physics for the life sciences increased. To understand better which elements of the student experience in these courses contribute to these gains, we surveyed students pre and post to measure their interest, self-efficacy, and assessment of physics relevance to the life sciences—taken together, "physics affinity." In this talk we report the findings of this study at three dissimilar institutions (one small private and two large public institutions with different approaches in their physics courses for life science students). Additionally, we also report the results of a pilot minimal intervention at one institution designed to support students' interest in physics and appreciation of relevance, while requiring minimal effort from the instructor.

(FC-03) | Poster Presentation Traditional | Key Features of a Successful Introductory Physics for Life Sciences (IPLS) Course Ecosystem

Presenting Author: Lundy Zheng, Swarthmore College

Additional Author | Drake Roth, Swarthmore College

Additional Author | Nikhil Tignor, Swarthmore College

Additional Author | Stephen Hackler, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Benjamin Geller, Swarthmore College

Prior longitudinal work in our group has shown that our Introductory Physics for Life Sciences (IPLS) course supports students in the development of (i) the ability to successfully use physical models in novel biological contexts, and (ii) positive attitudes toward the relevance of physics to the life sciences. To better understand how our course ecosystem (including the messaging, pedagogy, and curricular choices that collectively constitute the course environment) supports such long-term gains, we implemented survey check-ins with students every few weeks throughout the two-semester course. Data collected from this effort were unpacked via a series of case study interviews, and were triangulated with data collected using a "physics affinity" survey, an instrument that combines measures of student interest, self-efficacy, and sense of the relevance of physics to the life sciences. We report on our coordinated analyses of these data streams, highlighting the features of the course ecosystem that students found to be most essential for their growth.

(FC-04) | Poster Presentation Traditional | Building a Better Microscope: Physics Curriculum for Biology Courses

Presenting Author: Sarah McGregor, Keene State College

Additional Author | Loren Launen, Keene State College

Traditionally regarded as distinct scientific domains, the blending of physics and biology disciplines offers profound pedagogical benefits. We argue that the significance is not only integrating biology concepts into physics curricula but also reciprocally infusing physics teachings directly into biology courses. Many tools integral to biology, such as the microscope with its iconic status, have foundations in physics. However, the microscope often remains a black box for students, who lack an understanding for the underlying physics principles, making the microscope a prime subject for blending curriculum. Here we present a carefully scaffolded series of exploratory activities designed to illustrate the physics behind microscopy, culminating in the creation of a mock-microscope. By embedding this curriculum within both physics and biology courses, we aim to foster a comprehensive understanding of the interdisciplinary nature of scientific tools, and better prepare students for both using and troubleshooting in microscopy.

(FC-05) I Poster Presentation Traditional I Life Science Students Conceptions about Fluid Dynamics

Presenting Author: Dawn Meredith, University of New Hampshire

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | James Vesenka, University of New England

Additional Author | DJ Wagner, Grove City College

Additional Author | Dan Young, University of Delaware

In developing our Fluids Concept Evaluation, we interviewed 73 students from 10 diverse institutions. We share what we've learned from these interviews about how life science students think about fluid dynamics, focusing on Bernoulli's principle, viscous flow, and Reynolds number. Student answers are analyzed through the lens of cognitive resources. Project supported by NSF 2021273, 2021059, 2021261, and 2021224.

(FC-06) I Poster Presentation Traditional I An IPLS I Course Combining Several Pedagogical Threads at University of Massachusetts Amherst

Presenting Author: Brokk Toggerson, University of Massachusetts-Amherst

For the past decade, University of Massachusetts - Amherst has been developing a IPLS I course which integrates several different threads currently circulating within the PER literature: a topic list and order specifically for biology students, an explicit addressing of the differences between math-in-physics and math-in-math, computation, team-based learning (which uses a flipped model), project-based learning, open educational resources, and concept-first instruction. In this course, All of this is done at scale with five sections of 100 students each served every semester.

(FC-07) I Poster Presentation Traditional I Poster Presentations and Peer Review as an Alternative to Lab Reports

Presenting Author: Christopher Ertl, University of Massachusetts Amherst

In an effort to create a more authentic lab experience, we have refocused our lab goals to address (1) working in a team, (2) experimental design, (3) scientific communication, (4) peer review, and (5) data analysis. Students work with a team throughout the semester to complete 5 labs where they are charged with carrying out experiments mostly of their own design, and creating and presenting posters digitally. While half of the teams present, the other teams are required to complete peer reviews of 3 randomly assigned teams. The lab instructors also complete a review of each team and provide feedback. At the end, teams complete a review of themselves based on feedback from the instructors and their observations of how other teams completed the same lab assignment. Lab activities involve the evaluation of claims and models, and analyzing data with z scores, t tests, and graphical representations.

(FC-08) I Poster Presentation Traditional I A Large-Enrollment IPLS II Course at University of Massachusetts Amherst Developed with Biology and Chemistry Faculty

Presenting Author: Brokk Toggerson, University of Massachusetts-Amherst

Introductory Physics at University of Massachusetts – Amherst is a two-semester sequence. The second semester builds on skills from the first including: reading mathematical equations and team work. The context is a flipped classroom which meets in sections of 300 students at a time. This course focuses on the essential questions "What is an Electron?" and "What is Light?" while exploring authentic biological and chemical contexts. These contexts were developed in conjunction with biology and chemistry faculty at our campus using a mutual mentoring paradigm. Such collaboration ensures that the examples use biologically/chemically authentic language and interests. Collaborations go so far as to ensure that the timing and sequencing of topics supports inter-course transfer as students see the same topics in different courses within weeks and in ways that mutually support understanding.

(FC-09) I Poster Presentation Traditional I The TRIAGE Rubric as an Approach to Problem Solving

Presenting Author: Melissa Vigil, Marquette University

When working with IPLS students, students frequently lament that physics is not a memorization focused course or one in which plugging in numbers is sufficient for success. The mental model that I use with such students is that Physics teaches triage: the assessment of a situation by relevance or need especially to determine how resources will be used. Our IPLS students are familiar with this process from a medical perspective and soon come to see that a productive approach to problem solving in physics. A rubric used in introductory courses at Marquette University uses the word TRIAGE as a mnemonic for students in framing their problem-solving approach. Implementing this approach on homework and exams has led to significant improvement in organization and explanation on student work.

(FC-10) I Poster Roundtable I Using introductory physics models with data to answer real biomedical questions.

Presenting Author: Nancy Beverly, Mercy University

For every major physics topic, scenarios of the human body or biomedical context have been created where students use introductory physics models with data to answer real human or biomedical questions, so the results of calculations have meaning. The data is sometimes taken in class, but more often from referenced research articles, where the data has to be interpreted. This imparts to students the value of the conceptual and algebraic models of each topic. Several examples will be presented.

Session FD: Makerspaces and Project Based Learning II

Location: Lobby Level - Marina Ballroom II **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Thomas O'Kuma

(FD-01 10:00 AM-10:24 AM) I I Observations From a Makerspace in a Rural Public School

Presenting Author: Brian Lamore

In this presentation I will communicatae my obseravations, successes, and challenges regarding starting, managing, and teaching a Makerspace in a rural public school. I started the Makerspace 7 years ago, and prior to that I taught mainly physics.

(FD-02 10:24 AM-10:48 AM) I Interactive (e.g. panel, round table discussion, hands-on activity) I Teaching Kinematics through a Murder Mystery

Presenting Author: Joe Cossette, Minnetonka High School

In common kinematics units, teachers talk a lot about the problem solving methods used to solve distance, velocity, acceleration, and time. Most of the practice that is provided is very sterile and typically only involves the values that are clearly needed to answer the question. In reality, problems rarely present themselves in this way. In response to a growing fear that students are learning the math but losing the problem solving process, this challenge was written in the style of a murder mystery where students need to assemble clues and work together to apply the science and solve a mystery. The result is an experience that provides the motivation for students to take the lead in questioning, collaboration, and critical thinking as it applies to the content of the course. In this hands-on session, participants will get an opportunity to take a learner stance and complete the "Kinematics Crime Scene" task from the student perspective. Materials for this and other murder mystery lessons will be provided with a discussion about how to incorporate a similar format into other topics.

Session FE: PER: Student Reasoning II

Location: Lobby Level - Marina Ballroom III **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Ryan Sayer

(FE-01 10:00 AM-10:12 AM) I Contributed Talk (12 Minutes) I Improving Essential Skills Related to Covariational Reasoning

Presenting Author: Alexis Olsho, United States Air Force Academy

Covariational reasoning---consideration of how a change in one quantity affects another, related quantity---has been studied extensively by mathematics education researchers, and is considered to be central to students' success in algebra and calculus. Recently, covariational reasoning has also been recognized by physics education researchers as foundational to quantitative modeling in physics and other sciences. In this talk, I will describe the development and implementation of a computer-based, out-of-class intervention intended to improve introductory physics students' covariational reasoning. I will discuss preliminary results from the implementation of the intervention, and possible next steps for improving the intervention. I will discuss additional topics related to quantitative modeling in physics for which materials could be developed, using the existing intervention platform.

(FE-02 10:12 AM-10:24 AM) I Contributed Talk (12 Minutes) I Students' Reasoning with Multi-variable Expressions in the Context of Potential Difference

Presenting Author: Safana Ismael, North Dakota State University

Additional Author | Mila Kryjevskaia, North Dakota State University

Research suggests that some reasoning difficulties persist even after targeted instruction. One such instance is the student's incorrect reasoning with multi-variable expressions in the context of Electromagnetism in the calculus-based introductory physics course. This talk will focus on student reasoning with Potential Difference, DV=-WEF/qtest. Specifically, after relevant instruction, students struggle to recognize that if the value of a test charge moving between two points is changed, the potential difference between the two points remains the same. We designed instructional activities (a blend of web-based assignments and classroom instruction) to investigate students' thinking in the context of math and analogous physics problems. We interpret the results through the lens of the dual-process theory of reasoning. We will discuss implications for instruction and curriculum development.
This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

(FE-03 10:24 AM-10:36 AM) I Contributed Talk (12 Minutes) I Applying Dual-Process Theories to Introductory Students' Mathematical Reasoning in Physics

Presenting Author: Benjamin Lichy, University of Maine

Additional Author | MacKenzie R Stetzer, University of Maine

Additional Author | Mila Kryjevskaia, North Dakota State University

Research has shown that the nature of human reasoning itself may impact student reasoning in physics. In particular, while students may demonstrate the requisite knowledge and skills (mindware) by reasoning correctly on one question, they may abandon that same line of reasoning on an analogous question containing a salient distracting feature that leads to an intuitively appealing response. As part of a larger effort to investigate and support student reasoning in physics by leveraging dual-process theories of reasoning (DPToR), previous work in our collaborative project has applied the dual-process framework to student reasoning involving multi-variable physics expressions (such as the operational definition of the electric field) that published research has shown to be challenging for introductory students. In the current investigation, however, we have extended our work to examine student mathematical reasoning about functional dependence both in and out of physics contexts. In this talk, preliminary results will be presented and implications for research-based curriculum development will be discussed.
This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

(FE-04 10:36 AM-10:48 AM) I Contributed Talk (12 Minutes) I Investigating Differences in Student Reasoning Across Questions that Elicit Different Types of Intuitive Responses*

Presenting Author: Thomas Fittswood, University of Maine

Additional Author | Em Sowles, University of Maine

Additional Author | MacKenzie R Stetzer, University of Maine

Inconsistencies in student reasoning have been documented across a wide variety of physics contexts, and researchers have found that they frequently stem from the nature of human reasoning itself rather than from a lack of relevant knowledge and skills. A growing body of research has leveraged dual-process theories of reasoning (DPToR) as a framework to investigate these reasoning inconsistencies and as a guide for the development of interventions designed to better support reasoning. Much of this work focuses on questions that elicit intuitively appealing, incorrect answers. We have been designing and testing DPToR-aligned interventions that aim to help students productively engage in cognitive reflection and apply the knowledge and skills relevant to the correct solution, which they typically already possess. By administering analogous interventions to support student reasoning on questions in a variety of physics contexts, we seek to better understand how the specific nature of the intuitively appealing, incorrect response and the resources available to rationalize that response can impact how students engage with the intervention. In this talk, we will present intervention results and discuss implications for research-based curriculum development.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

Session FF: Teaching Quantum Mechanics to Promote Workforce Development IV

Location: Lobby Level - Marina Ballroom IV **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** John Roeder

(FF-01 10:00 AM-10:12 AM) I Contributed Talk (12 Minutes) I Eliciting and Organizing Expert Knowledge in Quantum Sensing and Measurement Through cConcept Mapping

Presenting Author: Ben Zwickl, Rochester Institute of Technology

Additional Author | Gregory Howland, Rochester Institute of Technology

Additional Author | Namitha Pradeep, Rochester Institute of Technology

Quantum systems and their unique behaviors will lead to significant improvements in computing, communication, and sensing. Of these three application areas, quantum sensing has received little attention within curriculum development. As a first step toward developing resources for quantum sensing education, we are conducting semi-structured interviews with 10 leading experts to understand how they describe the major ideas of quantum sensing and measurement. The interviews employ a concept-mapping activity where experts graphically connect their ideas to each other and to topics in other courses (e.g., undergraduate quantum mechanics or introductory quantum computing). Each interview focuses on a subset of ideas pertaining to the expertise of the interviewee. After creating and reviewing their concept maps, experts also discuss examples of minimum complexity that could be used for teaching and developing exercises. During the analysis, information across maps is integrated into a main high-level map and detailed sub-maps. The method of expert knowledge elicitation will be interesting to curriculum developers in any area of cutting edge science. The results around quantum sensing will be of interest to QIS educators who are seeking more detailed information about quantum sensing and how to teach it.

(FF-02 10:12 AM-10:24 AM) I Contributed Talk (12 Minutes) I Quantum Curriculum in the US: How Much Coursework in Quantum Mechanics is expected for Completion of a Four Year Physics Degree?

Presenting Author: Alexis Buzzell, University of Utah

Additional Author | Jordan Gerton, University of Utah

Additional Author | Tim Atherton, Tufts University

Additional Author | Ramon Barthelemy, University of Utah

Quantum mechanics is an integral course for physics students. An understanding of quantum concepts is imperative for enrollment in physics graduate programs, participating in research within physics-fields, and employment at companies developing quantum technologies. Utilizing a syllabi analysis and publicly available course catalogs, the required number of courses and classroom hours devoted to quantum concepts was determined in order to earn a four year degree in physics in the US. The syllabi were coded using an emergent coding method and binomial statistics. The syllabi were also coded to quantify which subtopics are taught most often in quantum mechanics and if institutions are using a spins first (using linear algebra) or wave functions (using differential equations) first pedagogical approach was used. This study provides evidence for the cohesiveness/variability of the quantum curriculum across institutions in the US, and contributes to the literature on quantum education in the US.

(FF-03 10:24 AM-10:36 AM) I Contributed Talk (12 Minutes) I Education for a Quantum Workforce: Student Perceptions of the Quantum Industry in a Physics Capstone Course

Presenting Author: Kristin Oliver, University of Colorado Boulder/JILA

Additional Author | Victoria Borish, University of Colorado Boulder/JILA

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Additional Author | Heather J Lewandowski, University of Colorado Boulder/JILA

As quantum technologies move from the research lab into the private sector, a growing workforce is needed, including many with a physics background. As part of a broader initiative to prepare students to enter the quantum industry directly after their undergraduate studies, a capstone course called “Quantum Forge” was created at the University of Colorado Boulder We followed the first cohort of Quantum Forge students through their year in the course in order to understand their perceptions of the quantum industry. Here, we present the students’ views about the quantum industry, focusing on two important ideas. First, students noticed a distinct lack of diversity within the industry, which affected their desire to become participants in it. Second, the students believed that holding a graduate degree, specifically a PhD, was crucial to entry into the quantum industry. This caused many students to indicate that they did not see a role for individuals with Bachelor’s degrees, such as themselves, in the industry. Through these two themes, we aim to understand student beliefs about the industry and share some implications of these views for the industry itself, as well as those seeking to educate students about it.

Session FG: Alternative Assessment (Invited Panel)

Location: Harbor Level, Lewis **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Debbie Andres

(FG-01 10:00 AM-10:48 AM) | | Towards Authentic Assessment: Content-driven Application Projects for Meaningful Learning

Presenting Author: Leslie Chamberlain, Harpeth Hall School

The focus and methods of assessments signal to students what we value as important. However, time constraints and the need to effectively evaluate content knowledge and skills can restrict the assessment options available to us. This presentation discusses the use of application projects as summative assessments for high school students. I share how we create challenging content-driven applications that encourage ongoing deep learning. These mini projects allow students to explore connections to society and understand how the content is relevant to their lives, all without detracting from core learning and evaluation objectives. Examples of these projects across multiple units will be shared, along with their connections to overarching themes and phenomena that can be explored throughout a unit. The assessment method, student guidelines, and results will be presented along with student work exemplars.

(FG-02 10:00 AM-10:48 AM) | | Ungrading Physics: Fostering Independence and Critical Thinking

Presenting Author: Sarah Formica, University of North Georgia

Join me in this insightful panel discussion as I share a retrospective on my 19 years of experience in undergraduate physics education, with a focus on the transformative power of ungrading. Departing from the conventional directive of "what to think," ungrading is a paradigm shift that accentuates the cultivation of critical thinking skills. I will delve into the profound changes witnessed in my teaching practice, emphasizing how ungrading serves as a powerful inclusive teaching method. By dismantling traditional grading structures, ungrading fosters an environment where students from diverse backgrounds and learning styles can thrive. This approach ensures that the educational journey is tailored to individual needs, promoting inclusivity and equity. Ungrading liberates students from the fear of punitive measures for mistakes, granting them the freedom to learn at their own pace. This freedom affords them the necessary time to comprehend and learn from these mistakes. Let's engage in a conversation on the impact of ungrading on student engagement, self-motivation, the cultivation of critical thinking skills, and the creation of an inclusive learning space. This panel will offer an opportunity to explore ungrading's potential in reshaping the dynamics of the student-teacher relationship and contributing to a more inclusive and equitable physics education experience.

Session FH: PER: Intro Topics

Location: Mezzanine Level - Douglass **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Jerome Licini

(FH-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Investigation of Student Understanding of the Terminal Speed Behavior of Falling Objects

Presenting Author: Ethan Dibeh, Western Washington University

Additional Author | Emily Moran, Western Washington University

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Noah Trostle, Western Washington Universityy

At Western Washington University, research is underway to investigate student understanding of the terminal speed behavior of falling objects. We have developed a two-part written task involving three spheres, of varying size and mass, each falling at their own terminal speed. In part 1, students rank the spheres according to the drag force exerted on them. In part 2, students rank the spheres according to their terminal speeds. We have found that students often focus on a single variable in the drag force equation, such as cross-sectional area, as the basis for ranking the drag force. Many students do not explicitly apply the $F_{net} = 0$ condition to the falling spheres and give rankings inconsistent with this general principle. In this talk, we discuss these results and share specific examples of student reasoning..

(FH-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | How to Use Multiple External Representations to Improve Learning in Physics: Results of an Intervention Study on Faraday's Law

Presenting Author: Andreas Lichtenberger, ETH Zurich

Additional Author | Tommi Kokkonen, University of Turku

Additional Author | Lennart Schalk, PH Schwyz

Learning physics concepts is typically supported by the use of multiple external representations (MERs), such as manipulatives, figures, graphs, and equations. An open question is whether there is a particularly effective way to sequence or combine MERs. The so-called concreteness fading approach suggests starting instruction with more concrete representations and gradually moving to more idealized representations. However, presenting different representations simultaneously may promote comparison and contrast of representations, which may enhance learning. In an experimental high school classroom study (N=187), we compared concreteness fading and simultaneous presentation of MERs for learning a challenging high school physics content, namely Faraday's law. We found no significant differences between the two conditions. Both approaches were equally effective. The results suggest that there are different ways to effectively use MERs in learning Faraday's law. We discuss the implications for research and practice.

(FH-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Bridging Mechanical and Thermal Energy: The Case of Bouncing Ball

Presenting Author: Edit Yerushalmi, Weizmann Institute of Science

Additional Author | Efrat Blau Barak, Weizmann Institute of Science

Additional Author | Boaz Katz, Weizmann Institute of Science

Secondary school physics commonly require students to identify energy forms and their transformations in mechanical phenomena (e.g. bouncing ball) to reinforce energy conservation. However, in most observed phenomena, energy is dissipated, and students and teachers have difficulty reasoning quantitatively on these transitions. The ball-and-spring computational model of a solid have proved productive to bridge between energy in mechanics problems and thermal energy concepts in college level introductory courses. We report an instructional module guiding middle school students in modeling a bouncing ball by means of a 2-dimensional ball-and-spring simulation. When released from height, it depicts the transformation of macroscopic mechanical energy into internal energy as the solid gradually comes to rest on the surface. Manipulating the number of balls allows students to visualize and discuss irreversibility. Over 50 middle school physics teachers have experienced the module in professional development workshops over the past two years. Preliminary findings will be discussed.

Session FI: The Mysterious World of the 2YC Professor

Location: Grand Ballroom D **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Jennifer Snyder

2YC professors are a diverse group and our work might be a bit of a mystery for many people. We exist in a space between High School and University instructors that may be unfamiliar. We know that many people wonder if teaching in a 2YC would be a good fit for them. This session intends to gather a panel of instructors from various 2YC's to answer questions about what their work entails - the joys and the challenges.

Panelists:

Shahida Dar, Mohawk Valley Community College

Anthony Escuadro, Harold Washington College

Tony Musumba, Riverside City College

Brittney VornDick, Durham Technical Community College

Moderator: Jennifer Snyder, San Diego Mesa College

Session FJ: PhysTEC: Modern Classrooms

Location: Grand Ballroom C **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Adam LaMee

(FJ-01 10:00 AM-10:48 AM) | | Improving Teacher Efficacy & Sustainability in a Student Centered Classroom

Presenting Author: Tracie Schroeder, Council Grove High School

Co-presenting Author | Jodi Hansen, Worthington High School

Co-presenting Author | Gerry Gagnon, Newton South High School

Acknowledging the crisis with a dwindling pipeline of Physics Teachers, it is more important than ever to find ways to recruit and retain teachers in the profession. In this session, we will model strategies that empower educators to use blended instruction, self-paced structures, and mastery-based learning to create a student-centered classroom. Teachers who have used this approach with students enjoy teaching more, have a renewed sense of hope for the future of education, and are more likely to view teaching as a sustainable career choice. Presenters will emphasize the importance of building independent learners by providing tools that encourage students to take ownership of their own education. This session will model a series of lessons exploring motion at a constant velocity based on the Modern Classroom Project. Participants will experience a student-centered classroom and how it can enhance student understanding, retention, and overall enthusiasm for the subject. Using this approach, teachers are able to connect with each student individually or in a small group setting on a daily basis as students progress through the lessons at a pace that matches their learning.

Session FK: Rethinking the Undergraduate Physics Curriculum

Location: Concourse Level - Commonwealth B **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Ernest Behringer

Topical Discussion: The AAPT has convened a working group to engage the physics community in a discussion regarding the status of the undergraduate physics curriculum in the U.S. and to explore possible changes to the curriculum. The working group deployed a survey and will report on the results as well as solicit input on curricular issues.

Session FL: Graduate Education Forum

Location: Grand Ballroom E **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Douglas Petkie

(FL-01 10:00 AM-10:48 AM) | | Improving Graduate School Searches

Presenting Author: Earl Blodgett, American Institute of Physics

Co-presenting Author | Christina Unger-Ramos, American Institute of Physics

Co-presenting Author | Brad Conrad, NIST

How do students learn about graduate programs in physics and astronomy? What are the most important criteria in picking which programs to apply? How can we help to connect the right programs with the right students? How do students access reliable information about those programs most effectively? Since 1965, AIP has published the Graduate Programs in Physics, Astronomy, and Related Fields, or what is now known as GradSchoolShopper (GSS). GSS is now completely on-line and continues to evolve to better serve the needs of both potential graduate students and graduate programs. The Fall issue of the SPS Observer magazine focuses on graduate school topics in close partnership with GSS. To maximize its reach, that issue is bundled with Physics Today and housed on both SPS and GSS websites.
In this presentation we will provide an overview of what GSS has offered in the past, what it presently offers and discuss ideas for future iterations that could improve the graduate school search process. The round table discussion will provide an opportunity for community input as well as further questions about GSS.

Session FM: Phenomenal Physics: Hands-on Experiences that Excite, Intrigue, and Motivate

Location: Concourse Level - Commonwealth A **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Jan Mader

(FM-01 10:00 AM-10:48 AM) | | Amazing Acoustics! Physics You Can Feel, See, and Hear!

Presenting Author: Daniel Davis, Harvard University

While most humans and many other animals rely on sound to communicate, it is almost uncanny when inanimate objects produce sound, particularly when spectacular or without apparent moving parts. Singing rods, Chladni and bell plates, Rijke tubes, Chinese spouting bowls, wine glasses, and Helmholtz resonators are fascinating and engaging examples not only of resonance, standing waves, normal modes, boundary conditions, wave velocity, frequency, and wavelength, but also subtler and often omitted concepts of feedback, phase, and self-oscillation. Experience and explore these marvels firsthand, and discover their rich history and utility connecting physics and music in compelling yet accessible ways.

Session FN: PER: Facilitating and Understanding Group Learning Strategies

Location: Lobby Level, Stone **Time:** 10–11 a.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Kathy Shan

(FN-01 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Invisible Labor in Introductory Collaborative Physics Labs

Presenting Author: Emma Hunt, UT Austin Physics

Additional Author | Andrew Loveridge, UT Austin Phsyics

Additional Author | Viranga Perera, UT Austin Physics

Additional Author | Jonathan Perry, UT Austin Physics

Additional Author | Matthew Dew, Cornell

Additional Author | Gregorio Ponti, Harvard

Physics labs are often one of the first places physics students develop essential peer collaboration practices. Based on qualitative assessment of one-on-one interviews and coded end of semester questionnaires, we offer evidence that women in introductory physics labs are more likely than men to assume group manager roles, despite the vast majority of lab students, including women, reporting there was rarely a group leader and no need for one. We discuss this tension through the lens of "invisible labor." In sociology, invisible labor is work that goes un-acknowledged as skilled or necessary and is often applied to household labor in nuclear families and service work in academic departments. Here we discuss what kinds of physics lab work constitute invisible labor, the ramifications in these lab settings, and potential solutions to group-work inequities this invisible labor lens suggests. We identify the potential for instructor-assigned roles to give students equal access to developing organization and leadership tasks, which are often invisible, while recognizing them as skills that are essential to successfully doing physics. To the extent labs are starting points for scientific identity, the seeds of invisible labor in academia, which itself is well documented, may be planted or enforced in preventable ways in collaborative lab settings.

(FN-02 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Emergent Explicit Regulation: Contrasting Group Behavior at Two Different Times

Presenting Author: Andrew Burns, Drury University

Co-presenting Author | Ying Cao, Drury University

Additional Author | Tong Wan, University of Central Florida

Additional Author | Pierre-Philippe A. Ouimet, University of Regina

Group work is commonly adopted in active learning science classrooms. We have identified a phenomenon in small-group activities where students adaptively respond to challenges, which we named Emergent Explicit Regulation (EER). Through qualitative analysis of video data of college freshmen engaged in various types of activities, we identified instances of EER and categorized them based on their target areas. In this work, we analyzed videos of a small group of four students, two identified as Deaf or Heard of Hearing (DHH). We coded two consecutive lab sessions of model construction related to the greenhouse effect. In this talk, we first present, for each session, the distribution of EER instances in different target areas among the students. We then contrast the distributions between the two sessions and tentatively relate the distinction to the nature of the tasks in those two sessions. We aim to generate educational implications for similar class settings.

(FN-03 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Contribution Grading – A Strategy to Encourage Accountability and Provide Flexibility in Group Work

Presenting Author: Scott Carr, Coastal Carolina University

Additional Author | Siming Guo, Coastal Carolina University

Working in groups is a commonly contentious aspect of undergraduate education due largely to the unequal effort of all group members. When students who contributed in different amounts towards the success of the project receive the same grade, it can cause resentment and contributes to negative perception of group work. To address this, we developed a system for grading group work we call Contribution Grading. We found that requiring students to allocate a portion of the assignment grade among themselves prior to receiving a grade has improved attitudes towards group work and provides a mechanism to account for discrepancies in effort toward the final product. In this presentation, I will share the details of the system along with an example implementation and student survey data.

(FN-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | A Qualitative Analysis of Undergraduate Student Perceptions of Teamwork in a Team-based Learning Physics Course

Presenting Author: Isaura Gallegos, Harvard University

In this study, I explored student perceptions of teamwork within a Team-Based Learning (TBL) undergraduate physics course. Teamwork, characterized by its dynamic and adaptable nature, facilitates peer learning and is linked to various positive learning outcomes. Despite its benefits, teamwork often faces challenges, particularly from students' negative perceptions stemming from prior teamwork experiences. This presentation will delve into the qualitative insights from a broader mixed-methods study, focusing on student perceptions of teamwork and their beliefs about how teamwork either enhances or hinders learning. Additionally, I will discuss the implications for how to introduce teamwork and position students to make the most out of collaborative learning.

Session GA: eXtended Reality (XR) in Astrophysics and More I

Location: Harbor Level, Harbor I **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Andre Bresges

(GA-01 2:00 PM-2:24 PM) | | Making the Invisible Visible – eXtended Reality to Ffoster Physics Education

Presenting Author: Jochen Kuhn, Ludwig-Maximilians-Universität München (LMU Munich), Faculty of Physics/Chair of Physics Education Research, Germany

Additional Author | Atakan Çoban, Ludwig-Maximilians-Universität München (LMU Munich), Faculty of Physics/Chair of Physics Education Research, Germany

Additional Author | Aishwarya Girdhar, Ludwig-Maximilians-Universität München (LMU Munich), Faculty of Physics/Chair of Physics Education Research, Germany

Additional Author | Laura Fabietti, Technische Universität München (TU Munich), Faculty of Physics, Dense and Strange Hadronic Matter, Munich, Germany

Additional Author | Jochen Weller, Ludwig-Maximilians-Universität München (LMU Munich), Faculty of Physics/Chair of Physics Education Research, Germany

Additional Author | Christoph Hoyer, Ludwig-Maximilians-Universität München (LMU Munich), Faculty of Physics/Chair of Physics Education Research, Germany

Physical phenomena are difficult to understand. One of the reasons for this is that they are difficult to experience because they are too far away, too fast or too slow or invisible to the naked eye in general. In addition there is broad evidence that providing different visualizations (so called multiple representations) are prerequisites for effective learning and problem solving. So eXtended Reality (Virtual and Augmented Reality) can address both of these aspects and can make connections in space and time accessible for learning. The flexibility, diversity and variety of different visualizations can also be used to promote students' representational skills across different topics. The talk presents the theoretical framework from physics education and learning theory and discusses practice-oriented examples.

(GA-02 2:24 PM-2:48 PM) | | XR in Astrophysics eEducation – Learning About Lunar Phases

Presenting Author: Christoph Hoyer, Ludwig-Maximilians-Universität München Chair of Physics Education

Additional Author | Raphael Cera, Ludwig-Maximilians-Universität München Chair of Physics Education

Additional Author | Aishwarya Girdhar, Ludwig-Maximilians-Universität München Chair of Physics Education

Additional Author | Max Warkentin, Ludwig-Maximilians-Universität München Chair of Physics Education

Additional Author | Atakan Çoban, Ludwig-Maximilians-Universität München Chair of Physics Education

Additional Author | Laura Fabbietti, Technische Universität München - Dense and Strange Hadronic Matter group

Numerous studies have shown that learners have many misconceptions about lunar phases. For this reason, considerable efforts have already been made in the past to develop learning units that make the formation of the phases of the moon understandable to learners. For some time now, new technologies have been entering the market that could be particularly suitable for learning about the phases of the moon. XR technologies seem particularly promising here. The talk presents a Virtual Reality (VR) application developed at the Chair of Physics Education at LMU Munich, which is based on an established and successful student laboratory module of the WorldWide Telescope Visualization Lab (WWT VizLab). Our expectation is that the special affordances of VR will make it possible to convey the development of lunar phases even more comprehensibly than was previously possible with traditional multimedia methods. In future, the conventional learning format and the new VR learning application will be compared in controlled studies in order to find out more about the specific advantages and disadvantages of the respective forms of learning.

Session GC: Examining the Introductory Physics for the Life Sciences (IPLS) Course

Location: Harbor Level, Harbor III **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** F Fatima

(GC-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Changes in Physics Affinity from Introductory Physics for Life Sciences at Three Institutions

Presenting Author: Nikhil Tignor, Swarthmore College

Additional Author | Drake Roth, Swarthmore College

Additional Author | Lundy Zheng, Swarthmore College

Additional Author | Lili Cui, University of Maryland Baltimore County

Additional Author | Dan Young, University of Delaware

Additional Author | Catherine H. Crouch, Swarthmore College

Recently, a national effort has focused on improving introductory physics for the life sciences (IPLS), both to optimize the content and skills taught and to support growth of interest and appreciation of the value of physics for the life sciences. We previously found that after such a course at one institution, student self-reported interest in physics and perception of relevance of physics for the life sciences increased. To understand better which elements of the student experience in these courses contribute to these gains, we surveyed students pre and post to measure their interest, self-efficacy, and assessment of physics relevance to the life sciences—taken together, "physics affinity." In this talk we report the findings of this study at three dissimilar institutions (one small private and two large public institutions with different approaches in their physics courses for life science students). Additionally, we also report the results of a pilot minimal intervention at one institution designed to support students' interest in physics and appreciation of relevance, while requiring minimal effort from the instructor.

(GC-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Key Features of a Successful Introductory Physics for Life Sciences (IPLS) Course Ecosystem

Presenting Author: Lundy Zheng, Swarthmore College

Additional Author | Drake Roth, Swarthmore College

Additional Author | Nikhil Tignor, Swarthmore College

Additional Author | Stephen Hackler, Swarthmore College

Additional Author | Benjamin Geller, Swarthmore College

Prior longitudinal work in our group has shown that our Introductory Physics for Life Sciences (IPLS) course supports students in the development of (i) the ability to successfully use physical models in novel biological contexts, and (ii) positive attitudes toward the relevance of physics to the life sciences. To better understand how our course ecosystem (including the messaging, pedagogy, and curricular choices that collectively constitute the course environment) supports such long-term gains, we implemented survey check-ins with students every few weeks throughout the two-semester course. Data collected from this effort were unpacked via a series of case study interviews, and were triangulated with data collected using a "physics affinity" survey, an instrument that combines measures of student interest, self-efficacy, and sense of the relevance of physics to the life sciences. We report on our coordinated analyses of these data streams, highlighting the features of the course ecosystem that students found to be most essential for their growth.

(GC-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Computation in the IPLS Course

Presenting Author: Peter Nelson, Fisk University

A new approach to the IPLS course is presented. Instead of kinematics, we start with diffusion because students already appreciate its central role from high school biology. Students start by playing the "Marble Game" with a ten-sided dice determining jumps of ten marbles between two boxes. Implementing it in Excel, they discover Fick's law of diffusion. Finite difference methods are then developed to predict and understand the Marble Game's ensemble-average behavior. Students then apply similar techniques to drug elimination, radioactive decay, osmosis, ligand binding, enzyme kinetics, the Boltzmann factor, entropy, phase equilibrium, random walks, membrane voltage, and the action potential to discover the consequences of model assumptions. Students validate their models by comparison with data from foundational experiments. Students thus discover for themselves that science is an evidence-based endeavor with testable hypotheses that are supported by experiment using authentic life-science applications of Physics.

(GC-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Breaking the Physics Syllabus

Presenting Author: Jason Puchalla, Princeton University

Physics stands as a critical, and at times vexing, bridge to graduation for nearly all science majors. Universities see a significant number of life science students enroll in physics at some point during their academic journey. Many universities support multiple classes to cater to differences in background and the desired level of proficiency upon completion. Still, in the vast majority of these classes, students encounter a syllabus that largely parallels the one designed for their counterparts in physics and engineering, progressing through units that highlight core concepts like kinematics, forces, energy, and momentum. While cross-disciplinary examples can enhance content delivery and messaging, continuing changes in extra-departmental perceptions of physics are hinted at by decreasing medical school and life science major requirements. In some situations, life science students might benefit from the subject matter, learning objectives, and schedules of a significantly repackaged course that better aligns with differing educational trajectories. This presentation explores the multifaceted considerations behind this approach, drawing on nine years of experience in offering a significantly repackaged class that grew from 15 enrolled students in 2015 to nearly 100 in 2024. Insights from both departmental and pedagogical perspectives will be shared, including details on class structure, demographics, teaching styles, survey results, and assessments.

Session GD: Labs and Apparatus: Upper Division Labs

Location: Lobby Level - Marina Ballroom II **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Michelle Chen

(GD-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Optical Trapping – An Advanced Undergraduate Laboratory Experiment Spanning the Disciplines of Physics and the Life Sciences.

Presenting Author: Aaron Pilarcik, Massachusetts Institute of Technology

Optical Trapping, a modern experiment in biophysics, allows students in the advanced undergraduate physics teaching laboratory to learn principals of both physics and the life sciences. The Optical Trap uses infrared laser light to trap biological samples ranging from plant vesicles to bacteria. Students can succesfully quantify and measure ultrasmall forces, of the piconewton scale, such as the strength of the myosin motors transporting vesicles along actin fibers in onion cells, and the forces exerted by flagella in the swimming motion of Escherichia coli bacteria.

(GD-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Soft Matter Viscoelasticity Laboratory for Undergraduates

Presenting Author: Ashley Carter, Amherst College

Additional Author | David Brown, Amherst College

Additional Author | Paolo Canigiula, Amherst College

Soft matter physics is one of the fastest growing fields in physics. Researchers in this field look at the physical properties of polymers, colloids, surfactants, liquid crystals, and amphiphiles. They study self-assembly of materials, non-equilibrium dynamics, wetting, surface tension, and viscoelasticity. However, there are very few soft matter experiments in the undergraduate laboratory. One way to create more soft matter labs is to repurpose the classic laboratory on measuring Brownian motion of micron-sized particles into a laboratory where you use the motion to measure the viscoelastic properties of the medium. Another way is buy a rheometer, which allows for the direct measurement of the viscoelastic properties. Here we outline several soft matter laboratories to measure the viscoelastic properties of household materials using either experiment. We also talk about possible student projects using the experiments to explore questions in food science.

(GD-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Takeaways from BFY4 Advanced Labs: Transformative Hubs for STEM Careers

Presenting Author: Joseph Kozminski, Lewis University

Additional Author | Eric Ayars, California State University Chico

Additional Author | Daniel Borrero Echeverry, Willamette University

The Fourth Conference on Laboratory Instruction Beyond the First Year of Physics (BFY4), which took place in Chico, CA, prior to the 2023 AAPT Summer Meeting, highlighted laboratory experiences that help students develop skills that they can transfer to graduate school and the STEM workforce. This conference was centered on hands-on workshop experiences designed to introduce instructors to new laboratory experiences that they incorporate in their labs, but also provided plenary talks, breakout sessions, poster sessions, and an advanced lab demo show. Networking opportunities allowed for dialog and community building with the hope that discussions started during BFY4 would continue beyond the conference. This talk will provide an overview of the conference and of the post-conference survey results.

Session GE: Science Communication and Informal Physics

Location: Lobby Level - Marina Ballroom III **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Salomon Itza

(GE-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Measuring Long-term Impacts of Informal Programs: A Mixed Methods Approach

Presenting Author: Jessica Hoehn, University of Colorado Boulder

Additional Author | Brean Prefontaine, Duke University

Additional Author | Turhan K Carroll, University of Georgia

Additional Author | Noah D Finkelstein, University of Colorado Boulder

Informal STEM education (ISE) programs have the potential to impact participants' STEM interest, identity, sense of belonging, self efficacy, and more broadly their trajectories in STEM. While research documents various immediate benefits of ISE programs, longitudinal studies of impact are less common, partly due to cost and logistical challenges. We present a low-cost, community-centered approach to documenting long-term impacts of one informal physics program on its youth participants. In this talk we present preliminary results from two years of data collection, including quantitative survey analysis and qualitative analysis of retrospective case studies. We discuss the mixed methods approach, challenges encountered thus far, plans for future work, and implications for other ISE programs looking to document long-term impacts.

(GE-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Investigating Youth Science Communication Practices in an Informal Environment

Presenting Author: Cai Cash, University of Colorado Boulder

Additional Author | Jessica R. Hoehn, University of Colorado Boulder

Additional Author | Noah D. Finkelstein, University of Colorado Boulder

Informal science education (ISE) programs are often designed to engage youth in scientific practices in a fun, interactive manner that can support development of science identities and sense of belonging. Measuring youth engagement in an informal learning environment is necessary to gauge the impacts of ISE programs, though it is often difficult due to the absence of formal assessments associated with more traditional learning environments. This talk investigates youth engagement in Partnerships for Informal Science Education in the Community (PISEC), a physics outreach program run through the University of Colorado Boulder. In this ISE program, youth participants perform experiments alongside adult mentors and document their experiences in science notebooks. Through content and thematic analyses of two different notebook formats, we find that the format of the notebook impacts the ways in which youth engage with science communication practices in PISEC. Sponsored by Jessica R. Hoehn

(GE-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Undergraduate STEM Ambassadors: The Impacts of Facilitating Informal STEM Activities In Your Own Community

Presenting Author: Brean Prefontaine, Duke University

Additional Author | Mallory Rice, California State University San Marcos

Additional Author | Edward Price, California State University San Marcos

Additional Author | Raquel Yoshinaga, California State University San Marcos

Additional Author | Kayleen Diaz, California State University San Marcos

STEM and physics education research have recognized the value of community engagement and outreach efforts for both facilitators and participants. Additionally, undergraduate and graduate STEM students often participate as facilitators of these spaces at least once throughout their academic careers. Previous research has shown that these experiences are particularly significant for facilitators because, among other things, they offer a community of practice that students can engage in, they provide avenues for developing teaching skills, and they help develop STEM and physics identities. This study seeks to understand the experiences of undergraduate students majoring in STEM who take on the role of STEM Ambassadors. These students, many of whom grew up in the same community, act as near-peer mentors and facilitate STEM-related makerspace activities for local youth. Through virtual interviews (held via Zoom) with approximately 25 STEM Ambassadors, we seek to further understand how facilitating informal STEM activities with youth who share similar formative experiences (i.e., growing up in the same or nearly community or sharing similar social identities) impacts STEM identity development.
This work was supported by NSF DRL # 2215653, "The Expansion of a Mobile Making Project That Engages Underserved Youth Across California in STEM."

(GE-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Science/Mythology: Narratives of Science in Colonial and Postcolonial India

Presenting Author: Rajive Tiwari, Belmont Abbey College

The presentation will look at popular-level scientific narratives in print media and elsewhere and discuss the political uses of these narratives. It will compare and contrast the narratives of the nineteenth century with ones from present day.

(GE-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | Reflecting to Learn in a Physics Multimedia Communication Course

Presenting Author: Steven Tarr, Georgia Institute of Technology

Additional Author | Emily Alicea-Muñoz, Georgia Institute of Technology

Science communication skills are considered essential learning objectives for undergraduate physics students. However, high enrollment and limited class resources present significant barriers to providing students ample opportunities to practice their formal presentation skills. We investigate the use of integrated critical reflection and peer evaluation activities in a senior seminar course both to improve student learning outcomes and to supplement highly restricted presentation time. Throughout the semester, each student delivers one 8-minute multimedia presentation on either their research or an upper-division course topic. Following each presentation, audience members complete one of two randomly assigned peer evaluations: a treatment form that prompts critical reflection or a control form that

does not. Each class period concludes with a short quiz on concepts presented in that day's presentations. We observe minimal differences in quiz scores between students in the control and treatment groups. Instead, we find that retention and transfer of presentation content correlate with certain metrics of presentation quality described in the Cognitive Theory of Multimedia Learning and with self-identified prior exposure to presentation topics.

Session GF: Teaching Quantum Mechanics to Promote Workforce Development V

Location: Lobby Level - Marina Ballroom IV **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Matthew Wright

(GF-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Fostering Mentorship Through Authentic High School Quantum Computing and Engineering Research

Presenting Author: Jennifer Wang, Massachusetts Institute of Technology

Co-presenting Author | Matthew Yeh, Harvard University

Retaining STEM students, especially from underrepresented groups, can be bolstered through positive mentorship programs where students have the opportunity for authentic research experiences. Quantum Engineering Research and You (QuERY) is a program jointly run by graduate students at MIT and Harvard working with public high school science teachers. It uses mentorship to teach students quantum science, engineering, and computing research skills. Students work in small groups over a semester with their graduate student mentor via videoconferencing to produce an authentic research project, culminating in an end-of-program research symposium where all mentors and students meet in person to share their work. Topics related to quantum science and engineering attract much interest and enthusiasm from student researchers. Some preliminary results of a study of student self-efficacy will be shared. Graduate students interested in mentorship are encouraged to attend.

(GF-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Students' Development of Quantum Concepts through Quantum Board Games

Presenting Author: Benjamin Dreyfus, George Mason University

Additional Author | Nancy Holincheck, George Mason University

Additional Author | Jessica L Rosenberg, George Mason University

We developed a quantum version of the board game Chutes and Ladders, to be played with a standard Chutes and Ladders board. The quantum version of the game illustrates concepts of superposition, probability, measurement, and (in the more advanced version) entanglement. We have run this activity with multiple groups who are new to quantum concepts including middle school students, high school students, undergraduates, and K-12 teachers. With some of the groups, Some of the groups designed their own quantum tabletop games after they learned about quantum concepts and played quantum Chutes and Ladders as an example. We present the evolution of the game as it has been adapted over time. We also present initial research results based on video data from students playing (and designing) these games, and identify conceptual themes that emerge from the interactions among students around this activity.

(GF-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Building Student Interest in Quantum Careers: The Pathways to Quantum Immersion Program

Presenting Author: Jessica Rosenberg, George Mason University

Additional Author | Nanacy Holincheck, Geoge Mason University

Additional Author | Benjamin Dreyfus, George Mason University

The Pathways to Quantum Summer Immersion Program introduces high school students to key quantum concepts and the jobs in quantum. The program has been run twice with a total of 37 participants. The program includes: (1) a two-week virtual program focused on helping students understand basic quantum concepts, (2) a one-week in-person experience in which students build on their understanding of the quantum key concepts and visit research labs, companies engaged in quantum, and an organization focused on quantum policy, (3) an optional follow-up in which students create a poster on their vision of future uses for quantum, and (4) an optional (application required) extended research experience in quantum. We examine survey responses and focus group interviews with participants to understand what students know about quantum careers and how understanding of their options and interactions with peers and experts through this program impacts their thinking.

(GF-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Quantum Journey in a Box: Tangible and Playful Activities to Introduce Quantum Concepts to Secondary Students

Presenting Author: Jean-Francois Van Huele, Brigham Young University

Co-presenting Author | Charlotte Whiteside, Salem Hills High School

We have developed "Quantum Journey in a Box", a unique offering to broaden access to quantum physics for secondary students. The "Box" contains several activities that allow the students to discover and interact with some of the key ideas from quantum information. The activities consist of card games, detective work, optical investigations, and shape matching. They illustrate the quantum concepts behind cloning, cryptography, polarization, and teleportation. An accompanying interactive workbook provides additional information and support. In this talk we will describe the activities behind the concepts and report on the actual use of the quantum box by students in a high school context.

(GF-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | A Hands-On Quantum Information Summer Workshop for STEM Students

Presenting Author: Catherine Herne, SUNY New Paltz

We present the design and implementation of a summer workshop on quantum information science for all STEM majors. The five-week summer session is designed for students from two-year or four-year colleges who are interested in quantum computing and quantum information topics but have no background in the field. The workshop outcomes are to offer students the opportunity to build the experimental and theoretical skills used in the quantum workforce as well as to implement a quantum computing algorithm. During the session students learn the basic principles of quantum computing, learn experimental techniques used in single-photon quantum experiments, and perform quantum mechanics algorithms. In this presentation we will describe the instructional design of the workshop and student reflections on their preparation for quantum information science work.

Session GG: K-12 Strategies to Facilitate Student Engagement

Location: Harbor Level, Lewis **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Marla Glover

(GG-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Connecting Middle Schoolers to Physics Careers

Presenting Author: Gabriella Kukon, The College of New Jersey

Additional Author | AJ Richards, The College of New Jersey

Prior work by our research group has indicated that many middle- and high-school students do not know about the variety of careers that a physics career can lead to. Nearly all of them see “engineer” or “teacher” as the only possible destinations for a physics graduate. In this talk, we describe an intervention we designed in which we developed a series of 40-minute modules, each of which explores a physics topic and a career closely associated with that topic (e.g., circuits and electrician), with the goal of exposing K-12 students to a wider range of physics-related careers. We piloted the modules in a local middle school classroom and collected reactions from the students and teacher. This presentation will describe the modules, present some of the feedback we received from the pilot, and detail the revisions we made in response.

(GG-02 2:12 PM-2:24 PM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Creating Engagement and Understanding in a Student-Centered Classroom that works at all levels of Physics Education.

Presenting Author: Chad Ronish, Sanford Underground Research Facility

Student understanding of physics content is directly related to the engagement they have in the classroom and the way they experience the content. This 1 hour interactive session will allow you to participate in a student-centered classroom where the teacher is directing the conversation, but talking strategies are inviting all of your students into the discussion. Your students will be engaged and empowered in a way that lets them investigate phenomena on their own terms while actively participating in the discussion. Your students will be empowered learners while exploring new content, comparing thoughts and ideas in a safe environment, holding each other accountable, and synthesizing new information with prior understandings. These pedagogical strategies will work at any education level and be adapted to any content area.

(GG-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Supporting Scientific Inquiry and Communication in the High School Physics Classroom

Presenting Author: Michelle Vanhala, Washtenaw Technical Middle College

How can we support physics students in participating in guided inquiry in the classroom? And how can science teachers build writing and communication skills to help students clearly report their results? I am a high school science teacher who also has a background in English and writing. I implemented a scaffolded experimental process in my high school physics classroom this winter that included an initial investigation to launch each unit of study with a guided writing structure to support students in analyzing and presenting their conclusions. In this session, I’ll share out my process (including all materials/resources) as well as my initial qualitative and quantitative results.

Session GH: PER Assessment Tools I

Location: Mezzanine Level - Douglass **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Paul DeStefano

(GH-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Assessing the Assessments with Cognitive Diagnostic Models: Skills Tested in Introductory Physics

Presenting Author: Vy Le, Iowa State University

Additional Author | Jayson M. Nissen, Nissen Education and Research Design

Additional Author | Xiuxiu Tang, Purdue University

Additional Author | Yuxiao Zhang, Purdue University

Additional Author | Amirreza Mehrabi, Purdue University

Additional Author | Jason W. Morphew, Purdue University

Instructors and researchers often use research-based assessments (RBAs) to assess students’ skills and knowledge. Adaptive assessments using cognitive diagnostic models provide significant advantages over fixed-length RBAs. As part of a broader project to develop the Mechanics Cognitive Diagnostic within an evidence-centered design framework, we identified and tested student models of four skills that cross content areas in introductory physics: apply vectors, conceptual relationships, algebra, and visualizations. We developed the student models in three steps. First, we based the model on learning objectives from instructors. Second, we coded the items on RBAs using the student models. Lastly, we then tested and refined this coding using the deterministic inputs, noisy ``and” gate (DINA) model. The data included 19,889 students who completed either the Force Concept Inventory, Force and Motion Conceptual Evaluation, or Energy and Momentum Conceptual Survey on the LASSO platform. The results indicated a good to adequate fit for the student models with high accuracies for classifying students with many of the skills. The items from these RBAs do not cover all of the skills, however, they will form a useful initial item bank.

(GH-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Initial Results in Evaluating Conscientiousness in Student Responses to Show-Work Exam Questions

Presenting Author: Heather Mei, The Ohio State University

Additional Author | Qiaoyi Liu, University of Colorado Boulder

Additional Author | Andrew Heckler, The Ohio State University

Conscientiousness can be an important factor in course performance that is often studied in the context of gender differences. Recent work has also documented that gender differences in performance can vary by specific graded components of the course. To better understand the relationship between gender, conscientiousness and performance on specific graded tasks, we have launched a project to analyze the level of conscientiousness of student responses to show-work exam questions in a calculus-based introductory physics course during the fall 2022 semester at a large public research university. We describe a coding scheme for "Show-Work Conscientiousness" (SWC), which include diagrams drawn, final answer markings, defined variables, straight lines, spacing, crossed out work, smudging, text elaboration, logic flow, photographic care, handwriting legibility, and holistic neatness. Further, we report on the inter-rater reliability and the Pearson correlation for all twelve dimensions of SWC. Finally, we present some preliminary results from the exploratory factor analysis to determine the underlying factors for SWC.

(GH-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Screening-target Item Performance at a Hispanic-serving Institution

Presenting Author: Brianna Santangelo, California State University, Sacramento

Research in cognitive psychology indicates that students need to possess content understanding (i.e., mindware) and apply appropriate reasoning strategies to productively reason. In response to this, researchers have developed a screening-target methodology and sequences of questions to evaluate students' understanding of physics content and their consistency in reasoning with it. Screening questions probe students' conceptual understanding and target questions require students to apply this understanding in scenarios that present reasoning challenges. We investigated the performance of these screening-target sequences at a Hispanic-serving institution (HSI) with a focus on sequences that had demonstrated strong correlation between screening item performance and target item performance in prior research. We will present two semesters of testing data from large enrollment introductory mechanics courses.

(GH-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Analysis of Features of Coexistence and Consistency of Students' Conceptual Understandings of Newton's Third Law from Novice to Expert

Presenting Author: Yi Ding, East China Normal University

There has been a growing consensus regarding the coexistence of misconceptions and scientific conceptions in the learning of physics over the past few years. The model analysis is shown as an intuitive mathematics tool to unveil the coexistence of misconceptions and scientific concepts when solving questions and the conceptual framework is an effective tool in elucidating the cognitive pathways of students situated in different levels of knowledge integration. In this study, we modeled student understanding of Newton's third law using a combination of knowledge integration levels and model states. Under the guidance of integrated models, a Model-based Knowledge Integration Assessment was developed which can assess the level of knowledge integration and model states at the same time. Both assessments and interviews underscore the effectiveness and consistency of model analysis in representing students' model states and conceptual framework in explaining students' model states. When assessing students' pure incorrect model state or mixed model state in multi-context problems, attention should be given to identifying frequent incorrect models and their corresponding reasoning pathways to enable effective guidance for physics teaching.

(GH-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | Creating Statistically Equivalent Versions of the Physics Inventory of Quantitative Literacy

Presenting Author: Trevor Smith, Rowan University

Additional Author | Brett Boyle, Rowan University

Additional Author | Philip Eaton, Stockton University

Additional Author | Charlotte Zimmerman, University of Washington

Additional Author | Alexis Olsho, United States Air Force Academy

Additional Author | Suzanne White Brahmia, University of Washington

The Physics Inventory of Quantitative Literacy (PIQL) is a 20-item multiple-choice test designed to measure the development of students' physics quantitative literacy (PQL). Evidence suggests that repeated testing across multiple courses, coupled with requiring up to 40 minutes for students to complete the test, may lead to testing fatigue and unreliable results. We seek to create two shorter 12-item versions of the PIQL (a.k.a. PIQLets) that are statistically and psychometrically equivalent to each other. We present preliminary results based on data collected by administering the full PIQL in three introductory physics courses at a large public university (N ~ 2500). We established constraints to ensure that each 12-item PIQLet version has the same content coverage and item formats, yielding 240 possible item combinations. Initial comparisons of PIQLet versions based on average student scores yielded results that were biased for high- and low-scoring students. More recent comparisons focus on using psychometric parameters from item response theory to seek to identify item combinations that could define PIQLets that are equivalent across all student data. We present the most recent results from our comparisons and discuss various metrics for defining test equivalence.
Supported by NSF Awards DUE-2214283 and DUE-2214765, and an NRC Research Associateship

Session GI: Stories of Survival from Disabled Physicists and Astronomers

Location: Grand Ballroom D **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Rebecca Lindell

(GI-01 2:00 PM-2:24 PM) | | Hiding MS

Presenting Author: Beth Thacker, Texas Tech University

When I was diagnosed with MS, I only told family and a few close friends. Even then, I often found that I was the one calming them down, instead of the reverse. So why tell anyone else? When I was asked if I was going to tell my department, my reaction was "God no, that would only make things worse." And in my head, I was thinking: "You already don't understand PER, now you want to not understand MS?" So, I was very successful at hiding my MS for quite a few years (I think), only telling people if I absolutely needed to. I will discuss my journey, including my decisions on health care for myself, focusing on what I can do, and working to overcome challenges. A lot has changed over the years and maybe it is time to stop hiding a diagnosis of MS.

(GI-02 2:24 PM-2:48 PM) | | Pity, Inspiration, Erasure, Solidarity: Ableism and Disability Politics in Physics

Presenting Author: Amy Robertson, Seattle Pacific University

In this talk, I will define ableism and discuss how it has shaped my experience as a disabled, neurodivergent, and chronically ill physicist. I will give examples of pity, inspiration, erasure, and solidarity – both internalized and experienced from others – and will offer some possibilities for a disability politic in physics and physics education.
**Please wear a high-filtration (KN-95 or N-95) mask during this talk (if you can) to make this space safe and accessible for me and others.

Session GJ: Teacher Training and Professional Development I

Location: Grand Ballroom C **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Frank Lock

(GJ-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Data from Classroom Educators to Frame University-K12 Engagement

Presenting Author: Kathleen Harper, Case Western Reserve University

One of Case Western Reserve University's presidential priorities is to enhance community engagement. In this vein, a growing group of faculty, staff, and students wish to increase our collaborations with local K-12 educators to positively impact STEM education. While some members of the university have extensive experience working with K-12 teachers and students, others do not. Further, we did not want to assume that the needs of these communities had been unaffected by covid. With input from local science teacher groups and CWRU's Gelfand STEM center, we created and distributed a survey to area high school STEM educators. Questions asked about what content and delivery methods would be most beneficial for their professional development. We also asked about what kinds of interactions with their students would have the greatest impact. The questions and responses will be presented, along with how these results are starting to impact upcoming events and activities.

(GJ-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | ChatGPT as a Tool for Developing Physics Teachers' Socratic Dialogue Skills

Presenting Author: Bor Gregorcic, Uppsala University

I will make a case that ChatGPT can be useful in pre-and in-service physics teacher training as a tool for developing "Socratic dialogue" skills. By "Socratic dialogue", I mean the skills of helping a learner improve their reasoning though asking strategically placed questions, but without providing direct validation or invalidation of the learner's statements. By presenting case studies of two conversations with ChatGPT, one from 2022 and one from 2024, I will demonstrate that ChatGPT has become more suitable for this task since the time of its first release. This is mainly due to the changes in its "personality" when engaging in conversations on the topic of physics.

(GJ-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Professional Development at the ARRL Teachers Institute on Wireless Technology

Presenting Author: Ronald Kumon, Kettering University

Co-presenting Author | Steve Goodgame, American Radio Relay League

The American Radio Relay League (ARRL) is the national association for Amateur Radio in the United States. Each year the ARRL sponsors a set of professional development programs to help teachers elevate STEM curricula with a focus on wireless technology. Through lectures and project-based learning, teachers are introduced to strategies for introducing basic electricity and electronics to students in the context of radio science and Amateur Radio. Hands-on projects have included (1) building a Yagi antenna and associated hardware for searching for a hidden transmitter ("foxhunting"), (2) building an FM radio kit, (3) setting up radio and antenna for operation in the field, (4) receiving signals from satellites, (5) using a software-defined radio for viewing radio spectra, (6) performing data acquisition and hardware control using the Arduino microcontroller, and (7) recording and interpreting digital signals from a wireless remote control. Upon successful completion of the course, teachers are given equipment and written materials that they can use to immediately implement the use of wireless technology in their classes. After completion of the first institute, teachers become eligible to apply for a subsequent institute focused on remote sensing and data analysis. For more information, see https://www.arrl.org/teachers-institute-on-wireless-technology.

(GJ-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Interactive In-person Communities for the Dissemination of Physics

Presenting Author: Alma Cabazos, Facultad de Ciencias, UABC

Additional Author | Juan Crisostomo Tapia, Facultad de Ciencias, UABC

Additional Author | Jesus Ramon Lerma, Facultad de Ciencias, UABC

Our work describes the engaging experience of conducting workshops and experimental demonstrations organized by our academic group, Teaching and Dissemination of Sciences, at the Universidad Autónoma de Baja California. These activities are a crucial component of the National Physics Outreach Program in Baja, California, involving students from diverse educational levels, ranging from kindergarten to high school. Our primary goal is to develop crucial cognitive abilities, encourage creativity, improve problem-solving skills, and promote efficient teamwork through active participation in these interactive initiatives. By linking the theoretical concepts used in creating scientific toys with everyday phenomena, we aim to create lively interactive communities in the pre-university education sector. In this work, we focus on the knowledge gained from workshops and experimental demonstrations in order to reinforce understanding of the concept of light. Our methodology involves using didactic resources such as mirrors, lenses, and prisms to create diverse scenarios that facilitate knowledge acquisition. We aim to enhance the student's understanding of optical instruments such as periscopes, kaleidoscopes, and telescopes by using the concepts of reflection and refraction. Our approach enables students to create these instruments using easily accessible materials.

Session GK: Women+ and Gender Minorities Roundtable

Location: Concourse Level - Commonwealth B **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Sarah Johnson

Come to this roundtable discussion about women+ and gender minorities in the field of physics. This will be a "safe space" for women+ and gender minorities to come together to discuss their lived experiences, barriers they have encountered and how they have persevered. We hope that this chance to speak with others especially helpful for those that may be the only woman+ or gender minority in their departments, programs or labs.

Session GL: Graduate Teaching Assistant Training

Location: Grand Ballroom E **Time:** 2–3 p.m **Date:** Tuesday, July 9, 2024 **Moderator:** Kateryna Kushnir Freidman

(GL-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Lessons Learned from a Decade of GTA Preparation

Presenting Author: Emily Alicea-Munoz, Georgia Institute of Technology

Graduate teaching assistants (GTAs) are essential members of the teaching staff in high-enrollment introductory physics courses. Because of their potentially large impact on student learning, it is important to provide them with appropriate preparation for teaching. In 2013 the School of Physics at Georgia Tech began offering a GTA preparation course for first-year PhD students that integrates pedagogy, physics, and professional development strategies. A decade has passed, and we now have a robust and comprehensive professional development program that has prepared nearly 250 GTAs for their roles in the lab, the classroom, and beyond. In this talk I describe the key elements that have made our program successful and some of the results from our program assessments.

(GL-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Evolution of Graduate Teaching Assistants' Instructional Practices

Presenting Author: David Seiden, University of Georgia

Additional Author | Madison Ogle, University of Georgia

Additional Author | Adithya Kuchibhotla, University of Georgia

Additional Author | Nandana Weliweriya, University of Georgia

Additional Author | Craig Wiegert, University of Georgia

In this study, we investigate a case study of a graduate teaching assistant (GTA) as they teach traditional introductory physics labs at a large public university in the Southeastern US. GTAs often teach the same material several times a semester depending on how many laboratory sections they teach. As they teach the material several times in a short timeframe, there is the potential for reflection and adaptation to improve teaching practices for the next section. We observed one GTA teaching the same lab in introductory mechanics several times in one week using the Laboratory Observation Protocol for Undergraduate STEM (LOPUS). In this talk, we will present a case study of how a GTA's teaching practices evolved over a single week through the lens of social semiotic resources. We will also discuss implications for future work in GTA preparation and professional development.

(GL-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Professional Development Programs for Graduate Teaching Assistants (GTAs) Across Three STEM Disciplines

Presenting Author: Nishchal Thapa Magar, George Mason University

Additional Author | Jessica L. Rosenberg, George Mason University

Additional Author | Jill K. Nelson, George Mason University

Additional Author | Marco Brizzolara, George Mason University

Graduate Teaching Assistants (GTAs) are often the lead instructors in recitations and undergraduate labs. Universities have adopted different strategies to prepare their GTAs for the course content, class management, and teaching methodologies needed to run an effective class. Some of these approaches include pre-semester workshops, academic year workshops, regular meetings with course coordinators, pedagogy courses, learning communities, and apprentice teaching. These different approaches have a range of goals from content knowledge to understanding research-based teaching methods, to practice in the classroom with feedback. In this talk, we present a framework for understanding the range of GTA professional development models and our approach to GTA training across three departments - Mathematics, Physics, and Computer Science (CS) - at George Mason University. The GTA professional development presented here evolved from local practices to meet the needs of a project that worked to embed more active and collaborative learning in large introductory courses.

(GL-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Studio Physics as a Tool for Professional Development for Graduate Teaching Assistants

Presenting Author: Brenna Petrelli, University of Connecticut

Additional Author | Diego Valente, University of Connecticut

Additional Author | Jason Hancock, University of Connecticut

Additional Author | Lea Santos, University of Connecticut

Additional Author | Xian Wu, University of Connecticut

Additional Author | Douglas Stewart, University of Connecticut

The University of Connecticut employs a large-scale implementation of a studio-based instructional model for its calculus-based introductory physics courses. This implementation has elevated the importance of collaborative group activities and sought to drive greater student engagement and improve learning outcomes. The impact of our Studio Physics program has been far reaching within our institution, as approximately 1000 undergraduate students each semester take our studio courses. Of no less importance, however, has been the impact of studio physics on our graduate students. Each semester our studio-based courses employ 60-65 Graduate Teaching Assistants (TAs). Graduate TAs in this course format are given duties both in and out of the classroom which closely mirror those of faculty instructors. In addition, graduate TAs are able to work closely with experienced faculty instructors to receive guidance and feedback on their teaching. We present a graduate student's perspective on the impact the studio physics format has had on their own development as teachers and share how this model and its pedagogical structure have provided a rich professional development opportunity for graduate students interested in pursuing careers in academia. We further describe the unique path from graduate Studio TA to Graduate IoR (Instructor of Record) at UConn.

Session GM: Engineering to Empower Students Through Understanding Heat Islands

Location: Concourse Level - Commonwealth A **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Shannon Morey

(GM-01 2:00 PM-2:48 PM) | | Engineering to Empower Students Through Understanding Heat Islands

Presenting Author: Shannon Morey, Knowles Teacher Initiatve, Abbott Lawrence Academy

Additional Author | Emily Berman, Knowles Teacher Initiative

This workshop will open with an introduction to the KnowlesTeacher Initiative's Engineering for Equitable Teaching Framework and how the framework can enhance learning experiences for students. This framework explores the ways in which societal issues that are relevant to students' lives can be integrated into engineering projects that teach students core science and math content. Attendees will put on their "student hat" to engage with components of an urban heat islands engineering design project. They will examine two neighboring communities in Massachusetts and connect how architects of the past have impacted the climate that residents experience today. We will review redlining and the heat island effect, connecting this topic to multiple content areas in the physics classroom and discussing how students used physics content to understand and develop ideas to help mitigate the urban heat island effect. We will end with time to think about how to integrate relevant community issues in our courses.

Session GN: PER: Intro Physics Learning Strategies I

Location: Lobby Level, Stone **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Eugene Mananga

(GN-01 2:00 PM-2:12 PM) | Contributed Talk (12 Minutes) | Employing a Hybrid of Problem-Solving and Retrieval Prompts in Introductory Physics

Presenting Author: Carina Rebello, Toronto Metropolitan University

Additional Author | Mina Megally, Toronto Metropolitan University

Additional Author | Atish Kabiraj, Toronto Metropolitan University

Retrieval practice, as used in psychology studies, relies on the learner retrieving the relevant information. A vast body of research shows that novices / beginning learners tend not to have well organized knowledge schemas. Therefore, learners will likely have difficulty retrieving productive resources for problem solving. Furthermore, problem solving performance tends to deteriorate for tasks with increasing complexity and most of the errors seem to be due to failure of retrieving the relevant information. Hence, there is a need to pair retrieval practice with a strategy that facilitates both encoding and retrieval of relevant schemas to facilitate productive problem-solving processes. In this study, retrieval prompts will be integrated within a four-step problem solving strategy utilizing reflective analysis. Here, we will describe the development of course materials promoting retrieval practice, our implementation strategies, and present student success findings from a first-year physics course.

(GN-02 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | Exploring the Effectiveness of an Inquiry-based Radioactivity Lab in Boosting Student interest in Physics

Presenting Author: Keshab Pokharel, University of Alaska Fairbanks

Additional Author | Michael M Hull, University of Alaska Fairbanks

This project evaluates the effectiveness of an inquiry-based radioactivity lab in enhancing undergraduate students' interest in Physics, in comparison to more scripted (traditional) labs. The inquiry-based lab begins with students constructing a cloud chamber, followed by engaging in inquiry using their cloud chambers as research tools. This entails students creating their questions and devising methods to address those creative questions independently. The activity aims to increase student interest by fostering a sense of ownership in their learning. To assess the lab, we collected data in the form of pretest/post-test surveys, in-class video recordings, and interviews with students and lab TAs. During this presentation, we will present the data collected, which includes student responses to surveys and interview prompts, both before and after the radioactivity lab. Our findings are relevant not only for advancing radioactivity education but also for informing teaching practices in Physics labs in general.

(GN-03 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Augmented Reality in Electromagnetism: Which Representations Best Support Students' Understanding?

Presenting Author: Bermann Steinmacher, ETH Zurich, Physics Education

Additional Author | Barbara Gränz, ETH Zurich, Physics Education

Additional Author | Andreas Lichtenberger, ETH Zurich, Physics Education

Additional Author | Kristin Altmeyer, Saarland University, Empirical Educational Research

Additional Author | Roland Brünken, Saarland University, Empirical Educational Research

Additional Author | Peter Edelsbrunner, ETH Zurich, Research on Learning and Instruction

We have developed an Augmented Reality (AR) learning setup in which students investigate the Lorentz force with different virtual representations of vector field models. In an experimental study with 77 high school students, we examined the effect of different representations and their combinations in AR on students' understanding. Depending on the experimental condition to which they were randomly assigned, students were presented with different virtual representations including vector fields, field lines, and a tripod. Using pre- and posttest, we found no significant differences in conceptual understanding between conditions. However, exploratory analysis revealed that groups employing the vector tripod either alone or in conjunction with other representations showed better learning results. Offering multiple virtual representations as opposed to a single representation did not seem to enhance or hamper the acquisition of conceptual knowledge. We discuss our findings and draw implications for the design of effective AR learning environments.

(GN-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Comparative Study on Electric Fields: Virtual Reality, Computer and Paper

Presenting Author: Roman Schmid, ETH Zurich

Additional Author | Andreas Vaterlaus, ETH Zurich

Additional Author | Andreas Lichtenberger, ETH Zurich

Virtual Reality (VR) is a promising technology for enhancing concept learning in physics. We developed a learning environment for VR with 18 tasks focused on electric potentials and electric fields. In an experimental study, 210 high school students were randomly divided into three groups. We compared the learning gains when the students solved the same tasks in our three-dimensional environment using VR headsets, with virtual visualizations on the computer, or with two-dimensional projections printed on paper. While there was no significant difference between the conditions overall, students with lower spatial abilities showed greater benefit from the immersive and more realistic three-dimensional experience with a VR headset. In addition, they were also significantly more motivated. We will present and discuss our VR learning environment and the results of the study in detail.

Session GO: Meeting Students Where They Are II

Location: Lobby Level - Otis **Time:** 2–3 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Raeghan Graessle

(GO-01 2:00PM-2:12 PM) | Contributed Talk (12 Minutes) | Applying Universal Design for Learning in Physics: Language & Symbols

Presenting Author: Bryanne McDonough, Boston University

Universal Design for Learning (UDL) is an evidence-based framework for teaching that aims to improve learning for all people. The three pillars of UDL are providing options for engagement, representation, and action & expression. By providing options for students to meet course expectations, educators can meet the needs and preferences of a diverse student population. In this presentation, I will briefly introduce and motivate the UDL guidelines before demonstrating the practical application of a guideline in physics and astronomy education. This talk will focus on the application of Guideline 2: Providing Options for Language & Symbols. Language and symbolism are fundamental in communicating and understanding physics, but lack of direct instruction and inconsistencies in their use lead to student confusion. In this talk, I will demonstrate how physics educators can introduce and reinforce language and symbols with several alternative representations to improve accessibility, clarity, and comprehension for all students.

(GO-02 2:12 PM-2:24 PM) | Contributed Talk (12 Minutes) | Student Support With Centralized "Help Room" Office Hours

Presenting Author: Jax Sanders, Marquette University

As part of a larger curriculum change for an introductory physics with calculus sequence, the teaching team began holding their office hours in a centralized public location in fall 2022. This appeared to enhance attendance and engagement, motivating the formalization of the Physics Help Room as a model for introductory physics support across the department. During the summer of 2023, the Help Room was renovated to improve comfort and accessibility, including augmenting lecture professor hours with peer tutors. To assess the impact of the the Help Room, we use a voluntary QR-code based sign-in system, with environmental "nudges" used to encourage sign-in. This data gathering allows us to articulate trends in student behavior and performance. Quantitative benefits of the help room include improved exam grades and office hour attendance rates. Qualitative benefits include improved student attitudes, engagement in social learning, and opportunities for impromptu personal and academic advising.

(GO-03 2:24 PM-2:36 PM) | Contributed Talk (12 Minutes) | More Is Not Enough: Using Exam Wrappers to Help First Generation Students Build Self-regulatory Skills in Physics Classes

Presenting Author: Sarah McGregor, Keene State College

Disadvantaged groups, spanning various categories like field-specific minorities, gender, socio-economic status, and First Generation College Students (FGCS), face diverse challenges, requiring a nuanced understanding of their unique barriers. Research indicates common struggles in self-efficacy and self-regulation within these groups. While reflective practices, such as exam wrappers, show promise in enhancing academic performance, their effectiveness in Physics and Engineering Courses varies. With minority and FGCS students though the self-efficacy can help drive, or sabotage, their struggling self-regulatory abilities. Therefore, this study details a self-efficacy/self-regulatory intervention in a University Physics Course at a high FGCS liberal arts school. We categorize and analyze the student responses in addition to academic scores, and analysis reveals initial academic improvement for many, but sustained progress necessitates not just to 'study more', but a student-proposed and individualized plan for changing study habits.

(GO-04 2:36 PM-2:48 PM) | Contributed Talk (12 Minutes) | Supporting High School Students to Succeed

Presenting Author: Joe Wyatt Jr, me

Many high school students begin a Physics class lacking the linguistic, mathematical, and critical thinking skills to succeed. This lack of preparation causes stress for the student and can be detrimental to learning. This talk will consider early strategies and interventions to mitigate deficiencies in these areas so that the student will be able to handle later topics successfully and with negligible stress.

(GO-05 2:48 PM-3:00 PM) | Contributed Talk (12 Minutes) | Hacking Learning: Revealing Students' Intrinsic Motivation Means They Have Fun Without Realizing That They Are Learning

Presenting Author: Christian Cardozo, Massachusetts Institute of Technology

Additional Author | Edward J Moriarty, Massachusetts Institute of Technology

Inspired by the hands-on teaching of the late Harold "Doc" Edgerton, the father of high-speed photography, the MIT Edgerton Center facilitates a number of hands-on "hackathon" events globally. A hackathon is a space where students' ideas rule the realm. No idea is too crazy—we have students select a project that they are interested in building; we've had things from drones to musical instruments, from underwater robots to furniture to arcade machines. Students form teams around similar interests and groups ultimately come out with a finished product—even if it's not the one they had planned. The power of students' intrinsic motivation, that is, something that they care about, ultimately charges them through, enthusiastically, the building of things they had never dreamed of—except that they did! Having their teachers around to witness these hackathons creates a powerful, precedent-setting example—eye-opening as they discover that they can learn from their students. These small-scale revolutions are helping to encourage grand-scale futures of project-based active learning with teamwork, soul, and fulfillment. "Mind, hand, and heart" is a concept we're accustomed to at MIT, but elsewhere it can represent a total paradigm shift which empowers students to have a say in how they learn and actually have fun while doing it. Sponsor: Elizabeth Cavicchi

Session HA: eXtended Reality (XR) in Astrophysics and More II

Location: Harbor Level, Harbor I **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Andre Bresges

(HA-01 3:00 PM-3:24 PM) | | From CERN's Particle Detector to Quantum Cryptography: Learning Abstract Contents with Augmented Reality and Chat GPT

Presenting Author: Aishwarya Girdhar, Ludwig Maximilian University of Munich

Additional Author | Atakan Çoban, Ludwig Maximilian University of Munich

Additional Author | David Dzsotjan , Ludwig Maximilian University of Munich

Additional Author | Max Warkentin , Ludwig Maximilian University of Munich

Additional Author | Laura Fabbietti , Technical University of Munich

Additional Author | Jochen Weller , Ludwig Maximilian University of Munich

Studies have shown that augmented reality (AR) can vividly represent abstract physical concepts for learners by combining real and virtual content, which can increase engagement, interest, and conceptual knowledge. In addition, direct integration of ChatGPT into AR now enables completely new possibilities for designing applications in an even more user-oriented manner. Building on this motivation, the presentation delves into the combination of AR with ChatGPT to enrich physics teaching and learning, especially in the complex areas of particle and quantum physics. For this, selected examples of learning applications will be presented, precisely about the ALICE particle detector and quantum cryptography. In particular, the special advantages of integrating real and virtual representations in AR and the possibilities that arise from integrating ChatGPT into the applications will be discussed. Additionally, current research projects on the two topics along with the first insights will also be presented.

(HA-02 3:24 PM-3:48 PM) | | Enabling Students to See Magnetic Fields — Teaching the Lorentz Force with AR

Presenting Author: Max Warkentin, LMU Munich, Faculty of Physics, Chair of Physics Education Research

Additional Author | Kristin Altmeyer, Saarland University, Empirical Educational Research

Additional Author | Roland Brünken, Saarland University, Empirical Educational Research

Additional Author | Peter Edelsbrunner, ETH Zurich, Research on Learning and Instruction

Additional Author | Barbara Gränz, ETH Zurich, Physics Education

Additional Author | Sarah Hofer, LMU Munich, Research on Learning and Instruction

Previous research has shown that guided inquiry-based learning as well as learning with multiple, external representations (MERs) can promote the understanding of complex phenomena in physics. In this context, augmented reality (AR) applications make it possible to superimpose real experiments with virtually presented information. This allows spatial and temporal contiguity to be established between the phenomenon and the supporting virtual visualizations which can help to reduce learners' cognitive load and to free up cognitive resources for learning. We present a research project that aims at developing an optimized AR learning environment for the investigation of the Lorentz force. By visualizing the fields relevant to the experiment in AR, a more direct investigation of the physical phenomenon can be achieved for the learner. However, it is not clear how MERs and guided inquiry-based learning can be combined to best promote learners' conceptual knowledge and representational skills. In the talk we will comprehensively introduce the AR learning environment that is used to investigate this question. Additionally, recent research results of the project will be presented and an insight into future research activities will be given.

Session HB: Ideas for Celebrating The 100th Anniversary of The Birth of Quantum

Location: Harbor Level, Harbor II **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** James Freericks

(HB-01 3:00 PM-3:25 PM) | | Hidden Variables: Rehabilitation of von Neumann's Analyss

Presenting Author: Robert Golub, North Carolina State University

Additional Author | Steve K. Lamoreaux, Yale University

In his book *The Mathematical Foundations of Quantum Mechanics*, (1932), J. von Neumann analysed the consequences of introducing hidden parameters (variables) into quantum mechanics. He showed that hidden variables cannot be incorporated into the existing theory of quantum mechanics without major modifications, and concluded that if they did exist, the theory would have already failed in situations where it has been successfully applied. von Neumann left open the possibility that the theory is not complete, and his analysis for internal consistency is the best that can be done for a self-referenced logical system (Goedel's theorem). This analysis has been strongly criticized and taken as an ``incorrect proof" against the existence of hidden variables. von Neumann's so-called proof isn't even wrong as such a proof does not exist. To our knowledge,a successful hidden variable extension to quantum mechanics with testable consequences has not yet been produced, suggesting that von Neumann's analysis is worthy of rehabilitation. We summarize von Neumann's discussion and the criticism it has attracted and show that examination of the logic of \ his argument leads to his conclusion that the existence of hidden variables capable of allowing the exact prediction of all physical quantities would contradict quantum mechanics, and require a vastly modified theory.

(HB-02 3:24 PM-3:48 PM) | | The 1925 Revolution of Matrix Mechanics and How to Celebrate It in Modern Quantum Mechanics Classes

Presenting Author: James Freericks, Georgetown University

Additional Author | Leanne Doughty, Georgetown University

Additional Author | Jason Tran, Georgetown University

In 1925, Heisenberg, Born, and Jordan developed matrix mechanics as a strategy to solve quantum-mechanical problems. While finite-sized matrix formulations are commonly taught in quantum instruction, the logic and detailed steps of the original matrix mechanics has become a lost art. In preparation for the 100th anniversary of the discovery of quantum mechanics, we present a modernized discussion of how matrix mechanics is formulated, how it is used to solve quantum-mechanical problems, and how it can be employed as the starting point for a postulate-based formulation of quantum-mechanics instruction. We focus on the harmonic oscillator to describe how quantum mechanics advanced from the Bohr-Sommerfeld quantization condition, to matrix mechanics, to the current abstract ladder-operator approach. We also describe a number of different activities that can be included in the quantum-mechanics classroom to celebrate this centennial.
This work was supported by the Air Force Office of Research under grant number FA9550-23-1-0378.

Session HC: Using and Contributing to the Living Physics Portal

Location: Harbor Level, Harbor III **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Juan Burciaga

(HC-01 3:00 PM-3:24 PM) | | Overcoming Barriers to Sharing Curricular Materials: Insights from a Living Physics Portal Experience

Presenting Author: Nancy Beverly, Mercy University

The Living Physics Portal is a dynamic platform for IPLS educators to share and evolve curricular materials. However, there are perceived and potential barriers that hinder educators from contributing at different stages of curricular evolution. There can be hesitation in the initial draft submission of original or adapted materials to the Community collection for sharing with registered physics educators only. There can be barriers in the progression of mature materials to submission to the open Vetted collection and then later to updated versions of Vetted materials. A journey through the hesitations and challenges many potential submitters may face, and what may help overcome them, will be conducted through a case study of the presenter's experience. Along the way, the submission processes with the advantages and disadvantages of each type of contribution will be reviewed.

(HC-02 3:24 PM-3:48 PM) | | Getting the Most Out of the Living Physics Portal

Presenting Author: Dawn Meredith, University of New Hampshire

The Portal is a community to support physics educators teaching life science students at the college level, and includes free open-source resources from 7 NSF-funded research-based curriculum development projects, as well as many others. You can connect as a casual browser, deep-diver, revisor, or author. In this talk, we will take a tour of the Portal to get a taste of the depth and breadth of resources available. The talk will also showcase NEXUS/Physics commercially available packages that provide an interactive text, a package of nearly 400 clicker questions (through Top Hat), and 600 homework problems (through Expert TA), most of which can be auto-graded. Funded by NSF grant DUE IUSE 1624006

Session HD: Upper Division Labs: SPS-ALPhA Awards

Location: Lobby Level - Marina Ballroom II **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Earl Blodgett

(HD-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | A Versatile Hong-Ou-Mandel Interference Experiment in Optical Fiber for the Undergraduate Laboratory

Presenting Author: Cyrus Bjurlin, University of Minnesota Twin Cities

Hong-Ou-Mandel (HOM) interference is a quantum optics laboratory experiment that has recently become more accessible to undergraduate students. The experiment consists of two identical photons simultaneously entering a non-polarizing beam splitter. The wavefunctions destructively interfere and the photon pairs bunch at the outputs whereas classically they are equally likely to exit different outputs. Due to the precision needed to achieve indistinguishability, setup and alignment of this experiment is often considered to be too difficult and time consuming to be appropriate for an undergraduate lab, with an end goal of merely demonstrating the HOM interference dip. We present an alternative optical fiber-based apparatus that gives a consistently reproducible experiment with interference occurring in a fused-fiber coupler instead of a traditional beam splitter. We use a commercially available fiber coupled biphoton source that requires minimal alignment and increases coherence length of the interference. In addition, our biphoton source provides direct temperature based control of the frequency degeneracy of the photon pairs produced, allowing for students to investigate physical properties of HOM interference such as coherence length and interference visibility. Through use of standard opto-mechanical parts combined with the commercially available fiber integrated biphoton source and laser, our apparatus is a middle ground between built-from-scratch and pre-aligned setups.

(HD-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | How to Implement Laboratory Projects in Microscopy

Presenting Author: Isabel Hardy, Amherst College

Co-presenting Author | Alejandra Velasquez, Amherst College

Laboratories are a great place for projects. Here, we describe how to implement laboratory projects in microscopy in introductory courses (electromagnetism or optics) or more advanced courses (optics, advanced laboratory, or biophysics) with standard 3-hour laboratory periods. Specifically, we describe the building of a complex microscope in stages using the engineering strategy of "minimum viable product", which we rename minimum viable project (MVP) for this context. In this strategy, students start by building the simplest microscope—the single-lens microscope—and work their way up to more complex microscopes, including: compound, high-magnification, darkfield, reflection, fluorescence, and total internal reflection fluorescence (TIRF).

(HD-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Acoustic Trapping in the Undergraduate Laboratory

Presenting Author: Alejandra Velasquez, Amherst College

Co-presenting Author | Isabel Hardy, Amherst College

Acoustic trapping is used in modern biophysics laboratories to study cell adhesion or aggregation, to sort particles, or to build model tissues. Here we create an acoustic trapping setup in liquid for an undergraduate laboratory that is low-cost, easy to build, and produces results in a 1-hour laboratory period. In this setup, we use a glass slide, cover slip, and double-sided tape to make the sample chamber. A piezo-electric transducer connected to a function generator serves as the acoustic source. We use this setup to measure the node spacing (millimeters) and the acoustic trap force (picoNewtons). We anticipate that the simplicity of the experimental setup, the tractability of the theoretical equations, and the richness of the research topics on the subject will lead to an undergraduate laboratory with many interesting student projects.

Session HE: 25 Years of Chandra X-ray Science Education

Location: Lobby Level - Marina Ballroom III **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Tracy Hodge

(HE-01 3:00 PM-3:24 PM) | | 25 Years of Chandra Xray Science Education

Presenting Author: Pamela Perry, NASA's Universe of Learning

Twenty-five years of Chandra X-ray Observatory informal STEM outreach has provided methods and tools to understand and visualize observational data with colors, sound and art. Visual representations of X-ray and other non-visible wavelength data involves the use of representative color techniques. The JS9 image analysis tools and astronomical image display is browser based, which makes them accessible for students and educators to study and model stellar and galactic objects. Students can construct their own research projects with archived data. MicroObservatory is a network of automated telescopes that can be controlled over the Internet. The telescopes were developed by scientists and educators at the Harvard-Smithsonian Center for Astrophysics and were designed to enable students to investigate deep sky phenomena. And what about experiencing data with other senses? Sonification is the process that translates data into sound, bringing the sounds and music of the universe to listeners. Other programs include the national online program PencilCode Recoloring the Universe, which teaches programing. Astrophoto Challenge allows students to create their own amazing images.

(HE-02 3:24 PM-3:48 PM) | | Enabling Learners to Explore the Invisible Universe with NASA's Chandra X-ray Observatory

Presenting Author: Rutuparna Das, Center for Astrophysics | Harvard & Smithsonian

25 years of Chandra X-ray observations of the universe bring with them 25 years of educational materials designed to bring the wonders of the cosmos to learners of all backgrounds. This talk will cover a variety of educational resources, aimed at learners of all ages. Our goals include reaching a large and diverse audience, establishing direct connections with scientists, developing materials that target underserved audiences, and using evidence-based best practices to create peer-reviewed materials and activities that encourage users toward deeper engagement. Coding excercises show learners how to communicate with the spacecraft, and how to process astronomical images. Accessible learning resources aim to empower all learners to explore the invisible universe; data sonifications and 3D prints in particular, while designed with blind and visually-impaired learners in mind, enable all learners to experience space through sound and touch. Our Women in STEM collection showcases the heroines of the astronomy world in an effort to provide girls with role models they can relate to. Learners have the chance to explore various science content themes through our collection of activities, and collaboration with NASA's Universe of Learning has led to a further plethora of resources for learners of all ages and backgrounds.

Session HF: Teaching Quantum Mechanics to Promote Workforce Development VI

Location: Lobby Level - Marina Ballroom IV **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Zac Patterson

(HF-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Quantum Computing for Everyone: A General Education Course

Presenting Author: Gina Passante, California State University, Fullerton

At California State University, Fullerton, we have recently developed a general education science course called "Quantum Computing for Everyone." This course is a 100-level science class with no prerequisites. The goals of the course are to introduce students of all backgrounds to the main ideas behind quantum computers and other quantum technologies without the use of math. In this talk, I will describe the course in its current iteration and share some of the lessons I've learned through the course's first run this Spring semester.

(HF-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | The QEd Project: Developing Quantum Conceptualization in UConn's STEM Curriculum

Presenting Author: Diego Valente, University of Connecticut

Additional Author | Lea Santos, University of Connecticut

Additional Author | Douglas Stewart, University of Connecticut

Additional Author | Max Meynig, University of Connecticut

Additional Author | Brenna Petrelli, University of Connecticut

Additional Author | Xian Wu, University of Connecticut

Quantum-CT is a large-scale statewide initiative with the goal of developing the state's workforce to meet the technical and development support needs of our industries in the 21st century. A key foundational piece supporting this initiative is the Quantum Education pillar (QEd), which consists of education initiatives spread across multiple institutions in the state of Connecticut developing quantum curriculum-based programs at all levels. We present the transformative curriculum initiatives being developed by the QEd group at the University of Connecticut. Our efforts seek to establish an educational pipeline for quantum curriculum starting as early as the high school level through our Early College Experience (ECE) program, and which feeds directly into our introductory physics courses. Additionally, we are working with industry and education partners inside and outside of Physics to comprehensively assess the needs of a 21st century quantum curriculum that transcends traditional quantum mechanics courses and engages students to understand phenomena and apply quantum concepts on a practical level as part of a continuing education certificate program.

Session HG: Facilitating Collaboration in K-12

Location: Harbor Level, Lewis **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Paul Miller

(HG-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Facilitating Explanation and Consensus Building in Physics Classrooms

Presenting Author: Brian Foley, Califonia State University Northridge

Co-presenting Author | Praisy Poluan, STEP UP

Scientific inquiry is more than simply conducting experiments, it includes a reasoning process that produces understanding of the results. Because class time is limited, teachers often cut to the chase and tell students what the correct interpretation is. However there are techniques that can streamline the discussion and consensus and let the students draw the correct conclusion from the data (van Zee & Minstrell, 1997). We propose a three-phase explanation and consensus building (ECB) process. The three phases can be summarized as:

* Initial explanations and voting
* Elaborating the top explanations
* Final voting and consensus recording

The ECB process can be completed in as little as one class period or longer for more complex phenomena. The end result is that the entire class both understands and agrees with the consensus view. Students engage in authentic science practices of constructing explanations, argumentation and communicating scientific ideas. Technology tools can play a key role in keeping track of the voting and annotating the explanations themselves. We use Socrative.com as a voting platform and Kialo-edu as an elaboration platform. The session will provide an opportunity to participate in the ECB and discuss the potential for students and teachers.

Emily H. van Zee & James Minstrell (1997) Reflective discourse: developing shared understandings in a physics classroom, International Journal of Science Education, 19:2, 209-228, DOI: 10.1080/0950069970190206

(HG-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | From MA to NJ: Peer Review in the High School Classroom

Presenting Author: Allison Daubert, Montrose School

Co-presenting Author | Danielle Buggé, West Windsor-Plainsboro High School South

During the 2023-2024 school year, high school students at the Montrose School in MA and West Windsor-Plainsboro High School South in NJ engaged in an authentic scientific communication project where they learned about scientific writing and built professional scientific communication skills. Over a series of four Investigative Science Learning Environment (ISLE) approach investigations, students in each school collaboratively wrote up their findings as laboratory reports and shared their work with physics classes at the other school. Students received instruction on the peer review process as used by professional scientists. Students then wrote peer reviews for a group in the other school's laboratory report and used this feedback to improve their lab reports before submitting them. Along the way, we learned a lot about teaching students how to provide effective feedback and work with feedback received. This talk discusses the evolution of the peer review process as well as student insights into the collaborative experience.

Funding for this project was provided by a Toshiba America Foundation grant.

(HG-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | What Did We Learn? Takeaways From a Cross-state Scientific Communication Project

Presenting Author: Danielle Bugge, West Windsor-Plainsboro High School South

Co-presenting Author | Allison Daubert, Montrose School

During the 2023-2024 school year, high school students at the Montrose School in MA and West Windsor-Plainsboro High School South in NJ engaged in an authentic scientific communication project where they learned about scientific writing and built professional scientific communication skills. Over the course of the school year, these first year physics students engaged in four Investigative Science Learning Environment (ISLE) approach investigations and collaboratively wrote up their findings as laboratory reports. They then shared their work with physics classes at the other school, wrote peer reviews for another group's laboratory report, and revised their work based on the feedback received. In this talk, we share examples of student growth throughout the peer review process. These include pre-post survey results, student reflections on the process and why it is important to science, changes in their scientific ability use, as well as student and teacher takeaways from engaging in a cross-state scientific collaboration and communication project.

Funding for this project was provided by a Toshiba America Foundation grant.

Session HH: PER Assessment Tools II

Location: Mezzanine Level - Douglass **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Paul DeStefano

HH-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Developing the Fluids Conceptual Evaluation

Presenting Author: DJ Wagner, Grove City College

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | James Vesenka, University of New England

Additional Author | Dan Young, University of Delaware

Additional Author | Dawn Meredith, University of New Hampshire

This work is part of a multi-institution collaboration developing the Fluids Conceptual Evaluation (FCE), a fair, valid, and reliable research-based conceptual fluids assessment for Introductory Physics for Life Science (IPLS) courses. The FCE will utilize two-tier multiple-choice items covering both fluid statics and dynamics. For each item, a Tier-1 question will ask for a factual answer, while the following Tier-2 question will ask the student to choose an explanation closest to their own reasoning. We plan to have a "final" set of around thirty two-tier questions ready by Fall, 2024. This talk will provide a brief overview of the FCE's development and unique attributes. IPLS instructors interested in serving as a field test site for the assessment should contact Project Lead Dawn Meredith.
Project supported by NSF 2021273, 2021059, 2021261, and 2021224.

(HH-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Introductory and Advanced Students' Difficulties with Heat Transfer Using a Validated Conceptual Survey Instrument

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | David E Meltzer, Arizona State University

Additional Author | Chandralekha Singh, University of Pittsburgh

We use the Survey of Thermodynamic Processes and First and Second Laws-Long (STPFaSL-Long), a research-based survey instrument with 78 items at the level of introductory physics, to investigate introductory and advanced students' difficulties with heat transfer. We present an analysis of data from 12 different introductory and advanced physics classes at five different higher education public institutions in the US in which the survey was administered in-person to more than 1000 students. We find that not only introductory but also advanced physics students have many common difficulties with these introductory thermodynamic concepts after traditional lecture-based instruction in relevant concepts. These findings are consistent with prior research in this area, but our results are also for several new contexts in addition to those used in prior research and for large numbers of both introductory and advanced students. Findings related to common difficulties of students with these concepts before and after traditional instruction in college physics courses can help instructors of these courses improve student understanding of these concepts. These findings can also be valuable for developing effective research-based curricula and pedagogies to reduce student difficulties and help students develop a functional understanding of heat transfer.

(HH-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Quantitative Assessment of Learning Assistants' Questioning Competencies Using Likert-scale Questions

Presenting Author: Jianlan Wang, Texas Tech University

Co-presenting Author | Beth Thacker, Texas Tech University

In the context of learning assistant (LA) preparation, the development of effective instructional practices like questioning is a crucial learning objective. Assessing LAs' questioning competencies is fundamental to their preparation, yet LA assessment has been primarily focused on their physics content knowledge, students' evaluation of LAs' performance, and LAs' self-perceived pedagogical competencies. Traditional qualitative methods, such as discourse analysis, pose challenges for large-scale analysis. In previous endeavors, we addressed this gap by designing and validating a video-coding scheme and free-response questions to assess LAs' competencies in asking effective guiding questions to address student difficulties. Building upon these efforts, this study aims to further enhance assessment efficiency by transforming pre-validated free-response questions into Likert-scale questions. In this approach, respondents rate provided options that represent various levels of questioning competencies, rather than providing their answers. We administered Likert-scale questions regarding classical mechanics and electromagnetism to evaluate the feasibility and validity of this method. We identified five categories of options for Likert-scale questions and developed empirical equations to derive pedagogical content knowledge regarding questioning (PCK-Q) from the collected ratings. We will discuss the viability of Likert-scale questions for large-scale assessment of PCK-Q and their application in LA preparation.

Session HI: Stories of Survival from Disabled Physicists and Astronomers II

Location: Grand Ballroom D **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Rebecca Lindell

(HI-01 3:00 PM-3:24 PM) | | Disabled Rage and Nihilism: My Experiences Having Apparent and Non-Apparent Impairments in Physics

Presenting Author: Daniel Oleynik, University of Central Florida

In high school, I was diagnosed with a degenerative hearing disorder requiring hearing aids. In undergraduate, I was diagnosed with both generalized anxiety disorder and depression. In graduate school, I was diagnosed with late-onset epilepsy after having a seizure out of stress, which caused a fracture in my spine, leading to wearing a back brace in the short-term, and having chronic back pain in the long term. Disability has been a part of my identity throughout my post-secondary career, necessitating a critical look at how I view myself and the statistics surrounding those with impairments that I've encountered in the research that I have done. As someone who is both disabled and a disability researcher, I wish to use this platform to go beyond the typical detachment with conference presentations and provide an impassioned and emotional look at what being disabled is like in physics, using both my personal experiences and data from the literature that explains and describes the realities of my existence.

(HI-02 3:24 PM-3:48 PM) | | Inside-Outsider: Neurodivergent Perspectives for Doing Research and Teaching

Presenting Author: Liam McDermott, Rutgers University

As a scholar of disability who is themselves disabled, I sit here in academia inside-out. An insider to the community I study and advocate for, I feel as if I am still an outsider to academia because of my disabled/neurodivergent identity. Born with congenital hearing loss, and being diagnosed with autism/ADHD/OCD as a teenager and young adult, I have been living as disabled and ardently vocalizing my identity as a disabled person for most of my life. My being disabled is normalized in my life. Yet, when I teach, I have to constantly remind students that I am disabled as I am often their first experience with a disabled person in a position of power. When I disclose that I am autistic/OCD/ADHD/hard of hearing, people who once treated me with dignity and respect suddenly have only contempt and derision to share. My experience being disabled has left me both bitter at the present treatment, yet at the same time full of pride and joy both in my community and myself. In this talk, I will untangle these contradictions, and discuss teaching and doing science with neurodivergent negativity, joy, and pride.

Session HJ: Teacher Training and Professional Development II

Location: Grand Ballroom C **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Aliyah Johnson

(HJ-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Enhancing STEM Teaching: Spreadsheet-based Active Learning for Educators

Presenting Author: Erika Cervantes Juárez, UPIIG-IPN

Additional Author | Daniel Sánchez Guzmán, UPIIG-IPN

The STEM approach focuses on the development of several skills, such as the computational thinking process, mathematical models, operations and abstractions, and physical knowledge of systems, science, and engineering concepts that can be applied to general aspects of life. The Learning Science and Engineering with Electronic Spreadsheets Cycle (LSEESC) has the goal of developing part of the skills described and has been tested with high school and engineering students, but it is necessary for teacher instruction to improve the implementation of the methodology. The present work describes the results of implementing a teacher course for the use and application of the LSEESC methodology with high school teachers who took the course, designed a learning intervention for their specific subjects, and presented how the strategy was implemented. Six learning strategies were developed by teachers covering the areas of mathematics, physics, chemistry, and biology; in all cases, the measure for the students and analytical revision were done by teachers with positive results in the learning process of their students.

(HJ-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Fostering Professional Development in the Global Nepali Physicists Community

Presenting Author: Rudra Kafle, Worcester Polytechnic Institute (WPI)

Student educators and new faculty members may not have received enough exposure to various pedagogical techniques which are essential to make student-learning effective and enjoyable. Some may have been trained in those skills by their home institutions, but not every institution has infrastructure such as a teaching and learning center to provide training to new educators. To expose physics students, postdocs, and faculty members to pedagogical skills, I started a virtual monthly talk series : 'Innovative Teaching and Scholarship of Teaching and Learning' in collaboration with the Association of Nepali Physicists in America (ANPA). Thus far, there have been over eight episodes featuring my own presentations and those of guest speakers from various US universities. We now include presentations on Physics Education Research in the series, as well.

I will be presenting on my professional development activities and their impact on the Nepali Physics Community here in the US, in Nepal and around the World.

Acknowledgment: The author would like to acknowledge the support from the Association of Nepali Physicists in America and the Physics Department at Worcester Polytechnic Institute.

(HJ-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Improving Preservice Teacher Understanding of Science & Engineering Practices Through a Physical Science Content Course and Internship Experience

Presenting Author: Nicole Glen, Bridgewater State University

Additional Author | Jeanne C Ingle, Bridgewater State University

Additional Author | Peter Holden, STARBASE at Hanscom Air Force Base

We intentionally linked two courses in our teacher preparation program: physical science content and teaching methodology for multilingual children, and included 20 hours in a multilingual classroom teaching physical science, engineering, and computer science at DoD STARBASE. We will describe the content knowledge development of the preservice teachers (PSTs) for the science and engineering practices. Pre- and post-test surveys included Teaching Engineering Self-Efficacy Scale (TESS) (Yoon et al., 2012) and Science Instructional Practices Survey (SIPS) (Hayes et al. 2016). Understanding of planning/carrying out investigations and developing/using models had the highest gains. PSTs better understood what those practices look like in a classroom and how they might enact them more often than initially thought. We examined content knowledge via open-ended assessments. PSTs struggled to portray balanced force and change of direction as acceleration through modeling; had success constructing explanations with evidence for the laws of motion, acceleration as a change in speed, and unbalanced force as movement of objects; struggled creating molecular models of matter to represent chemical change and properties of gas; had success creating particle models of solids, liquids, and physical changes. This presentation will discuss implications of these findings for other teacher preparation programs that include a physical science content course.

(HJ-04 3:36 PM-3:48 PM) I Interactive (e.g. panel, round table discussion, hands-on activity) I S.E.L. in the Science Classroom

Presenting Author: NADENE KLEIN, Douglas County School District

Science teachers were never trained to facilitate Social Emotional Learning in their classrooms/labs, however, we are being required to do so in many American schools. This session will give you the experience of several strategies and additional tips and tricks to successfully and authentically implement SEL with your students.

Session HK: Writing in Labs

Location: Concourse Level - Commonwealth B **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Catherine Herne

Laboratory courses are often where the majority of writing happens in our physics curricula. Come to this session to share your resources and strategies for teaching writing in labs and evaluating writing in labs. This will be an interactive session where we can present and discuss our instructional practices.

Session HL: PER Early Career Topical Group

Location: Grand Ballroom E **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Katherine Ansell

Postdocs, new faculty, and other junior Physics Education Research (PER) members are invited to this topical group to meet and discuss common issues. This session provides an opportunity to get connected with the PER Early Career Group and explore ways that you can be a part of this community during and outside of conferences.

Session HM: Engaging Students with Interactive Lecture Demonstrations (ILDs)

Location: Concourse Level - Commonwealth A **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** David Sokoloff

(HM-01 3:00 PM-3:48 PM) I I Engaging Students with Interactive Lecture Demonstrations (ILDs)

Presenting Author: David Sokoloff, University of Oregon

Co-presenting Author | Ronald K Thornton, Tufts University

The results of physics education research and the availability of computer-based tools have led to the development of research validated active learning strategies that have been demonstrated to enhance learning in the introductory physics course. (1), (2) One reason for the success of these materials is that they engage students to take an active role in their learning. This interactive session will demonstrate Interactive Lecture Demonstrations (ILDs) (3) through active audience participation. The session will include ILDs using clickers and video analysis, and also a virtual version—Home-Adapted ILDs—to be used in distance learning situations. (4) ILDs have been demonstrated to substantially improve conceptual learning.

1. David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, "RealTime Physics: Active Learning Labs Transforming the Introductory Laboratory," Eur. J. of Phys., 28 (2007), S83-S94.
2. David R. Sokoloff and Ronald K. Thornton, "Using Interactive Lecture Demonstrations to Create an Active Learning Environment," Phys. Teach. 35: 6, 340 (1997).
3. David R. Sokoloff and Ronald K. Thornton, Interactive Lecture Demonstrations (Wiley, Hoboken, NJ, 2004).
4. See https://pages.uoregon.edu/sokoloff/HomeAdaptedILDs.html

Session HN: PER: Intro Physics Learning Strategies II

Location: Lobby Level, Stone **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Eugene Mananga

(HN-01 3:00 PM-3:12 PM) I Contributed Talk (12 Minutes) I Aligning Instructor and Student Motivations Through a Conceptual Mastery System

Presenting Author: Ryen Burris, University of Maryland

Additional Author | Andrew Elby, University of Maryland

Our talk examines student perceptions of fairness of a conceptual mastery system of grading implemented in two undergraduate engineering physics classes. The Supported Mastery Assessment using Repeated Testing (SMART) system aims to incentivize conceptual learning by adding retake exams and removing partial-credit for correct equations/facts embedded within conceptually incorrect approaches. For non-traditional assessment structures to persist and spread, positive student response is vital. However, little research focuses on how students arrive at their evaluations of new structures. Using interview data, we argue that students engage in nuanced analysis of how assessment structures shape their behavior and then use this analysis to form their evaluations. A key element of this analysis centers around fairness. Some students determined fairness by comparing the different motivations of instructors and students: instructors want to increase conceptual understanding while students need good grades. These students deemed SMART "fair" when course structures/supports enabled students to successfully pursue conceptual understanding and to be rewarded for doing so—an alignment of motivations. For both instructors and researchers, we present a novel model of student evaluation of assessment structures that emphasizes students' self-awareness and strategic thinking.

(HN-02 3:12 PM-3:24 PM) I Contributed Talk (12 Minutes) I Social Positioning Correlates with Consensus Building in Two Contentious Board Meetings

Presenting Author: brant hinrichs, drury university

Additional Author | david brookes, california state at chico

Additional Author | jacob nass

This poster analyzes two examples of whiteboard meetings from a college calculus-based introductory physics course taught using University Modeling Instruction. In UMI, student small groups create a solution to the same problem on 2' × 3' whiteboards. They then sit in a large circle with whiteboards held facing in and conduct a student-led whole-class discussion to reach consensus. In the first example students overcame sharp disagreements to reach consensus, but in the second example they don't. We examine how social positioning contributed to students either successfully examining and resolving different ideas or failing to do so. Results from these two examples support the idea that meetings where "experts" soften their position by "hedging" more frequently are better able to overcome sharp initial disagreements to reach consensus on their own. Our analysis suggests that the way students position themselves in discussions may open or close the collaborative space to productive sense-making.

(HN-03 3:24 PM-3:36 PM) | Contributed Talk (12 Minutes) | Measuring Self-regulated Learning Behaviors in an Introductory Physics Course

Presenting Author: Danielle Maldonado, West Virginia University

Additional Author | John Stewart, West Virginia University

This talk will present results from an effort to develop an instrument to measure self-regulated learning behaviors in a college calculus-based introductory physics course. Students received short instructional segments on general self-regulation strategies and how to implement them in a physics environment. Students were encouraged to use these techniques in preparation for course exams, with four surveys offered throughout the semester asking students to evaluate the extent to which they exhibited certain self-regulated learning behaviors. A 5-factor model was proposed, with items to measure Planning, Time and Study Environment, Comprehension Monitoring, Peer Learning and Help-Seeking, and Evaluation. Exploratory factor analysis and confirmatory factor analysis suggested that a 3-factor model was more appropriate and that there was considerable correlation between the Planning, Comprehension Monitoring, and Evaluation constructs. This model was then used to compare students' self-regulated learning behaviors to a variety of cognitive and non-cognitive variables, including their end-of-semester course grades and self-efficacy.

(HN-04 3:36 PM-3:48 PM) | Contributed Talk (12 Minutes) | Search Engines or Study Groups: How Do Students Decide Where They Get Help?

Presenting Author: Alexander Conte, University of Maryland

Students are encouraged to work with their peers more than ever as our community comes to appreciate that collaboration can support student learning. However, many factors within and outside these collaborative spaces impact students' decisions to collaborate or use other resources to support their learning, like online homework solutions. To investigate how students navigate these decisions and why, we interviewed and collected autoethnographic reflections recordings from undergraduate engineering students. We will present a preliminary analysis of interview and reflection data from Ashley, an Engineering and Music double major who spends much of her time split between coursework, band practice, and social events on campus. She is also an unapologetic user of the popular homework solution website Chegg. We will explore how various factors such as course expectations, time optimization, and disciplinary identity, impact Ashley's decision-making around peer collaboration and using online solutions when seeking help with her coursework. This research will eventually inform instructional interventions aimed at supporting collaboration or discouraging unproductive solutions-use.

Session HO: Meeting Students Where They Are III

Location: Lobby Level - Otis **Time:** 3–4 p.m. **Date:** Tuesday, July 9, 2024 **Moderator:** Sara Collori

(HO-01 3:00 PM-3:12 PM) | Contributed Talk (12 Minutes) | Structure, Roles, and Group Learning in Undergraduate Labs

Presenting Author: Marie Calapa, Dartmouth College

Introductory lab sessions are often taught in 3-hour blocks, which most contemporary students find difficult to navigate effectively and may result in loss of interest and increased frustration. Implementing structure to the lab, facilitated by the instructor(s), allows for the development of better time management skills, direction in approaching the lab tasks, and opportunity for collaborative learning and peer teaching to break up the period. In tandem with a more structured layout of the lab time, the assignment of "roles" within a lab group can encourage participation and collaboration. This is especially effective in alternative assessment tools such as mixed group discussions and presentations, allowing ownership of understanding and knowledge. Enthusiasm and engagement were observed to increase with a more structured lab session, and I present a model for a suggested lab structure as well as anecdotal responses and reactions from students and instructors that participated in these labs.

(HO-02 3:12 PM-3:24 PM) | Contributed Talk (12 Minutes) | Multimodal Potential: The evolution of a college introductory physics course.

Presenting Author: James Vesenka, University of New England

Additional Author | Daniel Weller, University of New England

Additional Author | Matthew Badali, University of New England

This presentation chronicles the evolution of student grade distributions, assumed to reflect quantitative preparedness, in an active-learning guided-inquiry algebra-based physics course at a small New England college over a 25 year period. The student population slowly expanded from life science professional-school bound audience to a broader mix of life science majors yielding a corresponding bimodal grade distribution. Then came COVID. Today's varied student abilities and multimodal grade distribution provides for a very complex teaching environment. Engaging all the students cannot be done without additional assistance. To partially address this challenge, we have recruited prior students in the course and trained them as modeling-centered learning assistants (LAs). The LAs have been helpful to keep struggling students engaged in classroom activities. Given the correlation between grade distribution and major we are currently attempting to customize the introductory courses to better meet the needs of the students, one course to focus on Introductory Physics for the Life Sciences applications for better prepared students, and another course focusing on the scientific method in the context of Newtonian Mechanics. Critical buy-in from constituent programs, professional advising, and the internal academic review process will be described.

Fund for some Learning Assistants provided through the University of New England.

Session IA: PER: Using AI and Machine Learning

Location: Harbor Level, Harbor I **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Jason Puchalla

(IA-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Developing Three-Dimensional Learning Assessments using Generative-AI through prompt engineering

Presenting Author: Amogh Sirnoorkar, Purdue University

Additional Author | Sai Munikoti, Pacific Northwest National Laboratory

Additional Author | N. Sanjay Rebello, Purdue University

Recent reports in higher education have called for developing next-generation assessments that promote authentic knowledge-building practices. To facilitate this objective, "Three-Dimensional Learning (3-DL)" framework has been extensively adopted. This framework characterizes science learning along three "dimensions" namely (i) disciplinary core ideas - concepts central to understanding of a discipline, (ii) cross-cutting concepts - ideas that span across multiple disciplines, and scientific practices - disciplinary practices that are key to generating new knowledge. However, educators have highlighted several challenges in developing such assessments including contextualizing them in real-world scenarios. We seek to address these challenges by leveraging Generative-Artificial Intelligence through developing a prompt template customizable to the instructors' choices of content areas, scientific practices, core ideas, and cross-cutting concepts. Exemplar assessments generated from the template along with insights from piloting in introductory physics courses are discussed.

(IA-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Using Large Language Models as Grading Assistant for Student Responses to Physics Questions

Presenting Author: Zhongzhou Chen, University of Central Florida

Additional Author | Tong Wan, University of Central Florida

It is highly beneficial for learning if students can receive timely and proper feedback on their response to questions. Yet grading and writing feedback for verbal response can be extremely time consuming and resource intense. In this talk we introduce our exploratory efforts in using the Large Language Model (LLM) GPT-3.5 Turbo as a grading assistant, with the goal of saving approximately 70% of teacher's grading effort. We enhanced the performance of the LLM by engineering our prompt to provide the LLM with essential context knowledge, common student misconceptions from the PER literature, as well as between 5 – 10 example grading and feedback for each grading attempt. In one instance, 70% of the feedback generated by the LLM for students' response to a conceptual question is deemed as needing only minor edits by instructors, and students rated GPT generated feedback as more useful and more human like. We will also talk about more recent efforts in grading student response to numerical calculation questions.

(IA-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Emerging Themes from Clustering Student Scientific Argumentation Essays

Presenting Author: Winter Allen, Purdue University

Additional Author | N. Sanjay Rebello, Purdue University

Additional Author | Carina M Rebello, Toronto Metropolitan University

Student scientific argumentation is a long-researched topic in physics education research. In the recitation sections of a large enrollment introductory physics class at a large midwestern public university, we prompted students to provide arguments for their solutions to a physics problem they solved. Throughout the semester, they are taught to use the claim, evidence, and reasoning argumentation framework. In this multi-semester study, students received varying levels of scaffolding. We utilize machined learning and natural language processing methods to find any emerging themes of student responses each semester. We follow the computational grounded theory methodology proposed by Nelson (2020) and recently integrated into PER by Tschisgale et al. (2023). To analyze students' responses, we use Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN) by employing Bidirectional Encoder Representations from Transformers (BERT), Uniform Manifold Approximation and Projection for Dimension Reduction (UMAP), and SPACY. We report on the resulting emergent clusters. Supported in part by U.S. National Science Foundation grant 2111138.

(IA-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Investigating student reasoning on concept inventories using Machine Learning

Presenting Author: Sean Savage, Purdue University

Co-presenting Author | Amir Bralin, Purdue University

Co-presenting Author | N. Sanjay Rebello, Purdue University

Machine learning (ML) in recent years has become an important tool in education research. Large learning models (LLMs) have the potential to assess students' responses to questions and provide feedback. Previous research has shown that students' responses and reasoning on multiple-choice questions on the Force Concept Inventory are affected by the presence of distractors. We build on that research by using ML and LLMs, to categorize student open-ended responses to questions on the Energy and Momentum Conceptual Survey. We report on the results of analysis and the potential of these methods to analyze students' reasoning on open-ended physics conceptual questions. Supported in part by U.S. National Science Foundation grant 230065.

Session IB: Labs and Apparatus: Simulations, Demonstrations and Beyond

Location: Harbor Level, Harbor II **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Daniel Thompson

(IB-01 10:00 AM-10:12 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Projectile Motion with Authentic Launched Objects

Presenting Author: Virginia Card, Metropolitan StateUniversity

A series of lab activities was developed to provide hands-on experience with abstract physics concepts and contribute to lifelong learning by connecting classroom learning to authentic and commonly available tools, toys and materials, as part of the algebra-based introductory physics course at Metropolitan State University in St. Paul Minnesota, which serves a diverse group of mostly adult students majoring in Biology, Environmental Science and Life Sciences Teaching. For the lab on projectile motion, one of the most popular of these lab activities, a novel and surprisingly accurate laboratory apparatus was developed utilizing a dog ball launcher, construction clinometer, steel plate and radar gun. An even better apparatus with less readily available materials was also developed, utilizing a foam dart gun and toy car speed meter. This equipment can also be used for free-fall investigation involving purely vertical motion. Specifications, lab handouts, sample student results, and, if room dimensions permit, demonstrations will be provided.

(IB-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Using CMS Data in an Introductory Physics Course to Teach Momentum and Energy as well as Study Student Responses

Presenting Author: Marla Glover, Purdue University

Additional Author | Amir Bralin, Purdue University

Additional Author | Sanjay Rebello, Purdue University

Two main topics in introductory undergraduate Physics courses are momentum and energy. High Energy Physics uses the concepts of momentum and energy to study the fundamental particles. This talk will discuss the nature of the lab, the learning objectives met with the lab, the data generated from the lab, and some of the research that will be using the generated data. The lab uses the four-vector data of dimuon events from the CMS (Compact Muon Solenoid) Experiment. The students first encounter a visual representation of an event and are instructed on finding the invariant mass of the parent particle from the visual display. Then, students use that knowledge to write code to process 10,000 events, generating an invariant mass histogram. Throughout the process, the students are asked what they are doing and why they are doing it. The qualitative data generated will be used to study student reasoning, student computational thinking, and the use of natural language processing.

(IB-03 10:24 AM-10:36 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Pushing an Object on a Frictionless Surface Simulator

Presenting Author: Steven Sahyun, University of Wisconsin - Whitewater

A recently developed simulator to replicate the motion of an object on a frictionless surface during, and after, a push. There are adjustable parameters for force strength, push duration, and object mass so that students may experiment and observe the impact of these variables on the object's motion. The simulator was designed to enhance the Next Generation Physical Science and Everyday Thinking (NGPET) course's Energy Model of Interactions (EM) Module Activity 1 (A1) [1] in which students observe a video of a low-friction cart that is briefly pushed and allowed to coast with a simultaneous display of the cart's speed vs. time graph. The simulator not only replicates the recorded video, but also allows customization of the push duration, the force of the push, the mass of the object, and graph type. In addition, this tool complements discussions about force and acceleration found in the NGPET Force Model of Interactions (FM) Module Activity 1. This simulator can be accessed at: http://sahyun.net/physics/html5/block_push.htm. The HTML5 code was adapted from the "Ball dropping in a viscous fluid" simulator.[2]

[1] F. Goldberg et al. Next Gen PET (2016), Activate Learning, https://nextgenpet.activatelearning.com/

[2] A. Duffy (2018) http://physics.bu.edu/~duffy/HTML5/ball_in_viscous_fluid.html

(IB-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Apparatus Archaeology at MIT

Presenting Author: Christopher Miller, Massachusetts Institute of Technology

Situated in a major research university, our demonstration and laboratory groups have been privileged to accumulate artifacts from each era of educational and technological innovation. The resulting collection allows for a narrative history of locally-produced educational philosophies while showcasing items dating back to 1872's new "laboratory" method of instruction. Some found items include inventions from local manufacturers, objects last seen in the 1961 CENCO catalog, devices from from walk-in Corridor and advanced Project labs, kits from experiment-building introductory courses, and modern devices. Producing narratives for our objects provides a chance to reflect on how our role as presenters of experimental science can transform into a role of curation.

(IB-05 10:48 AM-11:00 AM) | Contributed Talk (12 Minutes) | Two Rolling Moment of Inertia Demonstrations: Faster, Extreme

Presenting Author: Jerome Licini, Lehigh University

"Moment of inertia" is often illustrated using the classic demonstration of a solid cylinder and a hollow cylinder with identical mass and radius rolling down an incline, in which the solid cylinder has a linear acceleration 4⁄3 times that of the hollow cylinder. 1) We demonstrate the design of a third, FASTER object that can be incorporated into virtually any hollow and solid cylinder demonstration. 2) Furthermore, we have made an extreme version of this apparatus that yields a factor of 25 in the acceleration ratio. These new demonstrations more effectively convey the impact of moment of inertia and how it is determined by the distribution of the mass of the object.

J.C. Licini, et al., "Enhanced Rolling Moment of Inertia Demonstration," Phys. Teach. 62 (2), 135-138 (2024).
https://www.lehigh.edu/~jcl3

Session IC: Three Perspectives on the Role of Computation in the Physics Class I

Location: Harbor Level, Harbor III **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Brandon Lunk

(IC-01 10:00 AM-10:24 AM) I I Computation as a Literacy in Physics

Presenting Author: Tor Ole Odden, University of Oslo, Norway

What does it mean to learn to use computation in physics? One way to look at it is as a new type of literacy that students are acquiring, similar to physics-specific ways of using mathematics and writing. From this perspective, learning computation is much more than just programming: it is a way of thinking and understanding the world that involves physics-specific ways of writing and using code, creating and evaluating models and data analyses, and communicating and collaborating with others around computational projects. In this talk, I will outline key elements necessary to become computationally literate in undergraduate physics, based on a longstanding research program on physics computational literacy. I will also outline what a complete undergraduate curriculum dedicated to physics computational literacy might look like, and highlight some of the benefits and challenges of this type of educational approach.

(IC-02 10:24 AM-10:48 AM) I I Computation as Scientific Inquiry

Presenting Author: Timothy Atherton, Tufts University

Computation is more than coding: it plays a key role in essentially all aspects of contemporary physics knowledge production. It's therefore natural to ask: How do we create educational environments that allow students to engage in these practices? We describe an educational environment, Computational Making, that aims to cultivate computational work interwoven with scientific inquiry, or even multiple embedded inquiries, and incorporates experimental design, physical and digital artifacts, data collection, model building and analysis. Features of the design that facilitate student work will be discussed, and connections to contemporary conversations in PER around agency will also be presented.

Session ID: Student Learning in the Introductory Lab I

Location: Lobby Level - Marina Ballroom II **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Amin Bayat Barooni

ID-01 10:00 AM-10:12 AM) I Contributed Talk (12 Minutes) I Progress Towards a Framework for Course-based Undergraduate Research Experiences (CUREs) in Physics

Presenting Author: Rachael Merritt, University of Colorado Boulder/JILA

Additional Author | Heather J Lewandowski, University of Colorado Boulder/JILA

Undergraduate research experiences have been shown to offer significant benefits to students, particularly students from marginalized groups. However, the oversubscription of traditional research opportunities combined with systemic barriers prevent many from participating in these experiences. A promising alternative are course-based undergraduate research experiences, or CUREs. CUREs are shown to have similar outcomes to traditional undergraduate research experiences, while reducing the barriers to participation and providing an authentic research experience to an entire cohort of students . Within STEM disciplines, physics has been identified as underrepresented in CURE implementation and a field where CUREs could be added. The broad scope of our work is to identify the physics-specific challenges and opportunities for creating and sustaining CUREs in physics programs to be able to support more CUREs being offered. As a first step, we conducted a series of interviews with physics faculty members from multiple institutions to collect faculty opinions and experiences with learning outcomes, sustainability of curricular changes, and the hurdles and opportunities to sustainably engage them and their students in CUREs. We will present results and findings from these interviews and the next steps in developing the framework and a second CURE at our own institution.

(ID-02 10:12 AM-10:24 AM) I Contributed Talk (12 Minutes) I The Tablecloth Trick with a Twist: A Simple Classroom Activity with Deep Physics

Presenting Author: Jason Hancock, University of Connecticut

Additional Author | Gabriel Kovacs, University of Connecticut

Additional Author | Sarah Trallero, University of Connecticut

Additional Author | Diego Valente, University of Connecticut

We describe a simple and low-technology approach for students to explore the classic tablecloth trick, with focus on considerations of the relative importance of both forces and torques which tend to tip objects. Theoretical considerations deliverable at the level of introductory first-semester mechanics are applied to develop a phase diagram separating the regimes of tipping without sliding and sliding without tipping as well as mixed regimes which appear sensitive to details. Experimental data and high speed videos are presented to enforce the conclusions and their limitations. We also note popular misconceptions about this phenomenon in popular culture and include evidence for the tipping effect from MythBusters experiments. In sum, we provide a developed lesson plan which provides an inexpensive, satisfying, multi-concept, self-guided activity set which is appropriate to active learning strategies delivered at the calculus-based physics level.

(ID-03 10:24 AM-10:3 AM) I Contributed Talk (12 Minutes) I Data Analysis Approach to an Introductory Physics Lab

Presenting Author: Tatiana Krivosheev, Clayton State University

Additional Author | Dmitriy Beznosko, Clayton State University

Additional Author | Alexander Iakovlev , Woodward Academy

Nowadays, the science students face many challenges after graduation, and teaching them useful lab skills is a step to provide needed support. Thus, the laboratory sections included with the introductory-level Physics I and II courses must provide a student with the practical experience and initial laboratory skills that would be further honed by upper-level courses such as data analysis. This presentation will show the updated experiments and the innovative methodology that were introduced with the use of the open-source tracker software (https://physlets.org/tracker/). This new methodology not only expanded the number of possible lab experiments, but provided students with ability to conduct some of the simple experiments at home using common household items, thus offering not only the exciting experience to students but also the backup option in the case of further restrictions to students attendance of lab facilities. With that approach, the labs are now a progression that introduces skills in a sequence to students, such as use of software for simple analysis, error analysis, making of a presentation and others.

(ID-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | HoPE, Hands on Physics Experience, an active, more experiential, and collaborative construction of knowledge and skills

Presenting Author: Mariam Regragui, "A Roiti" High School, Ferrara, Italy

Co-presenting Author | Maria Cristina Trevossoi, "A Roiti" High School, Ferrara, Italy

Co-presenting Author | Jacopo Boaretto, Department of Engineering, Ferrara University, Ferrara, Italy

Co-presenting Author | Edward Moriarty, Edgerton Center at MIT

Traditional teaching often relies on a transmissive model, where the teacher is the primary source of knowledge. Students passively absorb historical facts, with minimal interaction among peers and little opportunity for creativity or self-discovery. Their progress is measured through standardized tests that primarily assess memorization. However, in today's rapidly evolving world, how can such methods foster future innovators? Researchers suggest that active student involvement enhances motivation and learning outcomes. This paper documents an educational initiative at an Italian STEM-focused high school, inspired by MIT's methodologies of hands-on and collaborative learning. This initiative for Physics education integrates creative thinking, computational modeling, and engineering design. Collaborating in small groups led by peer mentors, students actively participate in project conception, research, construction, testing, and implementation. This active learning approach fosters deeper understanding and develops skills and democratic values. Aligned with Italian Ministerial Guidelines for STEM education, this approach not only enhances academic performance but also fosters inclusive environments, reduces gender gaps, and cultivates lifelong learning skills as recommended by the EU Council and educational policies like NGSS. By prioritizing hands-on, collaborative learning, this initiative also equips students for the demands of a dynamic job market and societal changes

Session IE: Innovations in Teaching Astronomy

Location: Lobby Level - Marina Ballroom III **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Tracy Hodge

(IE-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Explore Astronomy with Community Coordinated Modeling Center's Educational Heliophysics Tools

Presenting Author: Elana Resnick, NASA/GSFC/CCMC/ASRC Federal

Additional Author | Maria M Kuznetsova, NASA GSFC/CCMC

Additional Author | Leila Mays, NASA GSFC/CCMC

Additional Author | Yihua Zheng, NASA GSFC/CCMC

Additional Author | Jia Yue, NASA/GSFC/CCMC/CUA

Additional Author | Elon Olsson, NASA/GSFC/CCMC/CUA

Utilizing state-of-the-art modeling tools in an astronomy course can allow students to study the Sun both in real time and historical time studies to investigate its effects on our society. The Community Coordinated Modeling Center (CCMC) from NASA Goddard Space Flight Center (GSFC) offers tools to educators to enhance their astronomy education curriculum. The CCMC supports heliophysics educational endeavors such as space weather summer schools, contests, research visits and exchanges. The CCMC has developed new resources for the public to engage with the Sun's influence on Earth and the entire solar system during the year leading to a solar maximum. Come to this talk to learn about the new resources available on the CCMC's website to engage with the Heliophysics Big Year (HBY), the global celebration of solar science.

(IE-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | POGIL Activities in Astronomy

Presenting Author: Steven Cederbloom, University of Mount Union

POGIL (Process Oriented Guided Inquiry Learning) is an active learning pedagogy based on research into learning cycles. POGIL activities are designed to promote the development of "soft skills" such as critical thinking, communication, and information processing through the use of teamwork. Teams of students are guided through an exploration of an information-rich "model" (which often has both text and graphical elements) to discover important concepts. While POGIL was originally designed by several chemistry professors, activities have been written for a number of other disciplines. I will report on my work developing activities for teaching astronomy.

(IE-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Pondering the Universe: A Journey of Astronomical Curiosity

Presenting Author: Parimala Rajesh, MIT

My experience with innovations in teaching astronomy stem from my personal journey, starting with childhood curiosity about the starry dome that settles upon us at night. Encouraged by my family and teachers, I delved deeper into understanding celestial phenomena, starting out with naked eye observations. Through research for competitions, school, and personal projects, the focus shifted towards understanding the physics underlying celestial phenomena, deepening my fascination with the vastness of the cosmos. Now, as a university student studying aerospace engineering and astronomy, a formal education in observational astronomy and astrophysics has provided structured learning opportunities. Combining both aspects provided the theoretical framework to complement hands-on experience. From sketches of naked eye observations to the usage of more sophisticated observational and photographic equipment, this journey emphasized a progressive approach to understanding the skies. The innovation in teaching astronomy started with hands-on experiences, gradually introducing complexity to enhance comprehension. The incomprehensible magnitude of celestial bodies and their interactions continue to fascinate and inspire me in my pursuit of knowledge in this field. Due to the guidance of my teachers and the exposure to innovative methods, my journey as an astronomy student has been transformative in cultivating a deeper appreciation and curiosity for the mysteries of the universe.

Sponsored by Dr. Elizabeth Cavicchi.

Session IF: PER: Student Understanding of Quantum Mechanics I

Location: Lobby Level - Marina Ballroom IV **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Kristin Oliver

(IF-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Meta-Representational Competence in Quantum Mechanics Change of Basis Problems

Presenting Author: Idris Malik, North Dakota State University

Additional Author | Warren M Christensen, North Dakota State University

Meta-Representational Competence (MRC) "...[describes] the full range of capabilities that students (and others) have concerning the constructions and use of external representations" (diSessa and Sherin, 2000). Specific problems within Quantum Mechanics may be approached or perceived differently based on the notation used (either Dirac, Matrix, or Spinor notation). Here, we refer to "MRC" as the theoretical framework and "MRC concepts" as statements or ideas that could fall under the theoretical framework. A goal of this research was to see the degree to which students would freely talk about MRC concepts at different levels in an interview designed to elicit MRC conceptual thinking. Another goal is to further incorporate the MRC theoretical framework for use in PER. Semi-structured interviews presented physics students with content questions (adapted from Corsiglia et al. (2022)) and then asked them about MRC concepts directly, as they related to the content questions or other situations in Physics or Math. Student statements were coded to indicate both previously identified and novel facets of MRC in the context of change of basis problems in Quantum Mechanics. The Analysis of three student interviews demonstrates each student's distinct utility of MRC concepts and suggests extending the Wawro, Watson, and Christensen (2020) MRC statement codes.

Material based on work supported by NSF DUE 1560142, DUE 1852045, and PHY 1912152. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.

(IF-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Do Students Think that Objects Have a True Value?

Presenting Author: Natasha Holmes, Cornell University

Additional Author | Emily Smith, Cornell University

Additional Author | Mark Hughes, California State University - Fullerton

Additional Author | Gina Passante, California State University - Fullerton

The idea of a true value is central to the definitions of the point and set paradigms - a model for thinking about how students view measurements and uncertainty. Several studies have investigated how students' responses to questions about measurement and uncertainty reflect point- and set-like thinking, but none have asked the question of whether a true value exists. In this work, we focus on the idea of a deterministic true value and whether students (and expert physicists) think it exist. We asked over 700 participants from lower- and upper-division physics courses a survey question that directly asks whether objects have a true, definite position, primiming them to consider both classical and quantum objects. Results show differences between students at the lower-level and upper-level in their answer choice and their reasoning. These findings give more context into student thinking about measurements and uncertainty and raise questions about the role of instruction across the curriculum.This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-2139899 and National Science Foundation Grants No. DUE-1808945 and No. DUE-1809178.

(IF-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Assessing the Effect of Essential Skills Practice on Student Responses on Exams in an Upper Division Quantum Mechanics Course

Presenting Author: John Goldak, University of Washington

Additional Author | Peter S Shaffer, University of Washington

Solving problems is a primary way that students acquire "understanding" in quantum mechanics. This can be difficult, though, due to the new and unique mathematical formalism that underpins the theory. In order to help students become more comfortable with this mathematical formalism, we utilized the Essential Skills Framework by Brendon Mikula and Andrew Heckler from The Ohio State University [1] to build short, mastery-based homework assignments. These assignments were designed to help students develop accuracy and fluency in various common, "essential" skills used when solving a wide array of problems in quantum mechanics. In this talk, we will discuss our work in assessing the effectiveness of this practice in an upper-division quantum mechanics course. We will outline our efforts studying student responses to common exam questions, comparing patterns in answers from students who completed essential skills practice, to patterns in answers from students who did not, in an attempt to pinpoint various ways the practice affected student problem solving skills. This work was supported by the National Science Foundation under grant No. DUE-1821032.

[1]. D. Mikula and A. F. Heckler, Framework and implementation for improving physics essential skills via computer-based practice: Vector math, Physical Review Physics Education Research 13, 10.1103/PhysRevPhysEducRes.13.010122 (2017).

(IF-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Peer Interaction Facilitates Co-construction of Knowledge in Quantum Mechanics

Presenting Author: Chandralekha Singh, University of Pittsburgh

Co-presenting Author | Mary J. Brundage, University of Pittsburgh

Additional Author | Alysa Malespina, University of Pittsburgh

Collaborative learning with peers can lead to students learning from each other and solving physics problems correctly not only in situations in which one student knows how to solve the problems but also when none of the students can solve the problems alone. We define the rate of construction as the percentage of groups collaborating on problem solving that solve the problem correctly out of all groups having at least one member who answered correctly and one incorrectly while solving the same problem individually first. We define the rate of co-construction on each problem as the percentage of collaborating groups that answered it correctly if no student in the group individually answered it correctly before the collaborative work. In this study, we investigated student learning measured by student performance on a validated quantum mechanics survey and rates of construction and co-construction of knowledge when students first worked individually after lecture-based instruction in relevant concepts and then worked with peers during class without receiving any feedback from the course instructor. We find that construction of knowledge consistently occurred at a high rate during peer collaboration. However, rates of co-construction were more varied.

Session IG: PER: Professional Development

Location: Harbor Level - Lewis **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Mary Bridget Kustusch

(IG-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Using Groundskeeping to Examine Emerging Discipline-Based Education Researchers' Experiences

Presenting Author: Christian Solorio, Rochester Institute of Technology

Additional Author | Kayleigh M. Patterson, Rochester Institute of Technology

Additional Author | Christopher A.F. Hass

Additional Author | Eleanor C. Sayre, Kansas State University and RIT Castle

Additional Author | Scott V. Franklin, Rochester Institute of Technology

,Groundskeeping is a leadership style that centers individual growth and the transformation of environments to support that growth (Montgomery, 2020). Groundskeeping directs one's attention to both individual and ecosystem scales and the interfaces between the two. It contrasts in particular with gatekeeping leadership that centers uniform metrics of success by which individuals are measured. We adapt the groundskeeping leadership style into a framework that can be applied to the context of professional development for emerging education researchers. In this presentation, we discuss the philosophy of groundskeeping and the character of associated groundskeeping actions. Additionally, we use this framework to interpret interviews with emerging discipline-based education researchers reflecting on their professional development and entry into the DBER community.

(IG-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | What Goes intoPursuing a Collaborative Self-study of Undergraduate Students' Learning of Quantum Physics?

Presenting Author: Chandra Turpen, University of Maryland, College Park

In this talk, I will reflect on my experiences co-chairing a collaborative team of physics faculty focused on assessing students' preparedness for and success in learning quantum physics in our undergraduate program. Our collaborative self-study approach involved orienting with curiosity toward understanding students' experiences in our department and considering what we could collectively do to improve students' experiences. This work draws from a "practitioner-as-researcher model," where "stakeholders produce knowledge within a local context in order to identify local problems and take action to solve them" (Bensimon et al, 2004). Physics departmental stakeholders engaged in collective inquiry to bring about individual and organizational change. In this talk, I will describe: (a) the various roles PER folks may play in these spaces, (b) the tensions and dilemmas that arise, and (c) the ways in which particular PER tools, theories, methods become relevant (or not) to the pragmatic work being pursued. I emphasize the importance of coming to a shared understanding of the needs for change, building trusting relationships, and bringing PER tools in a "just-in-time" way.

Montgomery, B. (2020). Academic Leadership: Gatekeeping or Groundskeeping? The Journal of Values-Based Leadership, 13(2). https://doi.org/10.22543/0733.132.1316

(IG-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | How Emerging Discipline-Based Education Researchers Perceive Their Growth from Professional Development

Presenting Author: Kayleigh Patterson, Rochester Institute of Technology

Additional Author | Scott Franklin, Rochester Institute of Technology

Additional Author | Christian Solorio , Rochester Institute of Technology

Additional Author | Eleanor Sayre, Kansas State University and RIT CASTLE

I present results from a qualitative study on Emerging Discipline-Based Education Researchers (EDBERs) and how they acquire and utilize research-specific skills. Participants are chosen from past participants in the Professional development for Emerging Education Researcher (PEER) Institute, which holds extended, intense professional development workshops to foster research project design. Participants, all at least one year out of a PEER workshop, were asked about specific activities they found memorable and specific skills they learned that they now utilize in their current research. Participants discussed generative writing, generating and refining research questions, choosing appropriate theoretical frameworks, and learning specific methodologies as key skills learned. Multiple participants also expressed a strong desire to attend a subsequent workshop, articulating both an opportunity to continue their development while at a new, more advanced, stage of their research and to having a well-structured time to conduct research.

Session IH: PER: Assessment Tools- FCI

Location: Mezzanine Level - Douglass **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Robin Bjorkquist

(IH-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Designing Chained Computerized Adaptive Testing for the Force Concept Inventory

Presenting Author: Jun-ichiro Yasuda, Nagoya University

Additional Author | Michael Malvern Hull, University of Alaska Fairbanks

Additional Author | Naohiro Mae, Osaka University

Additional Author | Kentaro Kojima, Kyushu University

Administering assessment tests before and after instruction is commonly used to measure the pedagogical effect. After collecting the pre- and post-test scores, we calculate a statistic such as average normalized gain and analyze the average change in students' understanding after instruction. To shorten the test time, Yasuda et al. suggested the use of computerized adaptive testing (CAT), a practice in which a computer administers successive test items to match the current estimate of the student's proficiency. Although CAT provides possible solutions to reduce test time, there are still specific issues associated with the pre-post paradigm, for example, limiting the ability to observe the evolution of their conceptual understanding throughout the duration of the course. To address the issues, we propose increasing the frequency of CAT-based assessments during the course, while further reducing the test length per class, thus decreasing the total number of test items during the course. For that purpose, we utilize a CAT algorithm including collateral information, which we call Chained-CAT. In this talk, we present the design of the algorithm for Chained-CAT developed in the first phase of our research project, a preliminary result of analyzing its efficiency by numerical simulation, and discuss the feasibility of this system.

(IH-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Is the FCI biased across the intersections of gender and race?

Presenting Author: John Buncher, North Dakota State University

Additional Author | Jayson M Nissen, Nissen Education Research and Design

Additional Author | Ben Van Dusen, Iowa State University

Additional Author | Robert M Talbot, University of Colorado Denvery

Research-based assessments (RBAs) allow researchers and practitioners to compare student performance across different contexts and institutions. In recent years, research attention has focused on the student populations these RBAs were initially developed with because much of that research was done with "samples of convenience" that were predominantly white men. Traxler et al. found that the Force Concept Inventory (FCI) behaved differently for men and women using Differential Item Functioning (DIF). In this work, we extend their research in two ways. First, we test the FCI for DIF across the intersection of gender and race for Asian, Black, Hispanic, White, and White Hispanic men and women. Second, we apply the Eaton and Willoughby five factor model of the FCI to interpret the results of the DIF analysis. We found that the pattern of DIF follows the five factor model. The alignment of DIF with this factor structure, along with the measurement invariance of this structure across these 10 social identities, indicate that the items on the FCI are likely not biased, but are instead measuring real differences in physics knowledge among these groups. We frame these differences as educational debts that society owes to these marginalized groups that physics instruction needs to actively repay.

(IH-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | Misconceptions are Patterns of Wrong Answers on the FCI

Presenting Author: Aaron Adair, MIT

| David E Pritchard, MITY

Particular student misconceptions should result in associated patterns of wrong answers (distractors) on research-designed multiple choice instruments. We find misconceptions by using our Bayesian realization of the most general IRT model, the Multidimensional Nominal (normalized) Categories (choices per question) item response Models (MNCM (1)) to generate discriminations for each choice for each question. A non-orthogonal bi-quartamin rotation then emphasized only the "wrongest" distractors (most negative discrimination) for each dimension which are the misconceptions. On the FCI we found known misconceptions (Impetus, Circular Impetus, and Active or Larger Object Applies more Force) (2) and one new one: No Inertia (velocity immediately follows force). We find similar misconception patterns, but with more or less prevalence at different colleges. We also show the surprisingly small effect of randomizing 5% of all student responses. Our code is available on git-hub and we are happy to share them.

(1) Revuelta, J. (2014). Multidimensional ítem response model for nominal variables. Applied Psychological Measurement, 38(7), 549–562
(2) Halloun, I. A., & Hestenes, D. (1998). Common sense concepts about motion, 1056(1985). http://doi.org/10.1119/1.14031
IH: PER: Assessment Tools- FCI

Session II: PER: Exploring Student Success

Location: Grand Ballroom D T **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Martin Kamela

(II-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Skills for Guiding Students' Career Success in a Physics Class

Presenting Author: Camila Atencio, Florida International University

Additional Author | Emiliano Garcia, Florida International University

Additional Author | Tomas Gonzalez, Florida International University

Additional Author | Emely Lopez, Florida International University

Additional Author | Sony Raymond, Florida International University

Additional Author | Idaykis Rodriguez, Florida International University

Students develop skills throughout their undergraduate physics classes that become useful for their future career practices. These skills or competencies can be categorized between universally applicable (Hernández-Pina & Monroy, 2015) or content-based skills (H. Passow & J. Passow, 2017). Students in the algebra based introductory physics course were interviewed about their perceptions of skills and competencies they might need in their future career. Thematic analysis of these interviews showed that students mainly mentioned skills into two main categories; universally applicable skills like time management and communication skills and content-based skills like knowledge of course concepts. Motivated to make their introductory physics experience more useful for a diverse set of majors, we are consciencely designing the classroom experiences to develop these skills for their future. That is, these building blocks and tools will be effective for their future career success. By identifying and incorporating the skills and competencies into the daily physics curriculum, we can attend to students' career aspirations and shape their recognition of the physics experience as useful.

Fuensanta Hernández-Pina, Fuensanta Monroy, Psicología Educativa, Volume 21, Issue 1, 2015, Pages 11-16, ISSN 1135-755X, https://doi.org/10.1016/j.pse.2015.02.001
Passow, H.J. and Passow, C.H. (2017); A Systematic Review. J. Eng. Educ., 106: 475-526.

(II-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Exploring the Impact of Pre-Class Reflection on Student Engagement and Persistence in Introductory Physics

Presenting Author: Mohamed Abdelhafez, MIT

Additional Author | Shams El-Adawy, MIT

Research studies show that metacognition interventions positively impact academic performance. In our talk, we investigate the effects of a metacognitive optional assignment administered before class on student engagement and persistence in our introductory physics courses, in particular our introduction to electricity and magnetism course. The metacognitive activity, labeled "Second Chance", provides the opportunity for students to reflect on what went right and wrong in their understanding of the physics concept in the pre-class work. We explored the relationship between student responses in this self-reflection activity with engagement metrics such as class attendance, answers to concept questions in class and assignment completion. In this talk, we share some of our preliminary results about emergent patterns. By further exploring the impact of this activity, we hope to gain deeper insights into how metacognition interventions can impact engagement and persistence in introductory physics courses.

(II-03 10:24 AM-10:36 AM) I Contributed Talk (12 Minutes) I Anxiety, Growth Mindset, and its Role in Physics Classrooms

Presenting Author: Sony Raymond, Florida International University

Additional Author | Camila Atencio, Florida International University

Additional Author | Tomas Gonzalez, Florida International University

Additional Author | Emiliano Gonzalez, Florida International University

Additional Author | Emely Lopez, Florida International University

Co-presenting Author | Idaykis Rodriguez, Florida International University

Introductory physics students majoring in the life sciences report to being afraid of physics and having high levels of anxiety coming into their physics courses. Anxiety arises when students recognize that their cognitive abilities are overwhelmed by academic demands, thus their performance is altered (Macauley, K., Plummer, L., Bemis, C., Brock, G., Larson, C., & Spangler, J. (2018)). This can have detrimental effects on their success in physics courses and their persistence. This study analyzes interviews of 11 introductory physics students that have taken algebra-based physics. We analyzed their experiences and perceptions of physics to better understand their needs for their future careers. Focusing on moments they shared to experiencing anxiety in physics, we used a growth mindset framework to interpret their experiences and how some students mitigate their own anxiety. These findings suggest how growth mindset becomes an essential component to mitigate anxiety and help students succeed in physics. We extrapolated strategies, stories, and skills students developed throughout their physics courses within growth-mindset to guide curricular development and activities for future implementation. These strategies and skills in growth mindset in physics will become a major part of our Algebra-based introductory curriculum and instructor strategies.

Macauley, K., Plummer, L., Bemis, C., Brock, G., Larson, C., & Spangler, J. (2018). Health Professions Education, 4(3), 176–185.

(II-04 10:36 AM-10:48 AM) I Contributed Talk (12 Minutes) I Improving the Introductory Algebra-based Physics Experience for Pre-Health Students: Analysis of Expectancy-Values in an Active Learning Environment

Presenting Author: Tomas Gonzalez Hernandez, Florida International University

Co-presenting Author | Idaykis Rodriguez, Florida International University

Students in Algebra-Based physics are generally anxious about physics and often delay their physics experience in college to the last few semesters. This project is motivated to improve these students' experience in their introductory physics course to have positive attitudes toward physics and less anxiety. At Florida International University (FIU), the Algebra-based physics course is composed predominantly of Pre-Health track (Pre-med, Pre-dental, Pre-PA, and Pre-vet.) majors with most of those students also pursuing a degree in STEM and showing themselves to be anxious about physics. Using Expectancy-value theory, we gauge students' experiences with physics and measure their motivations to persist in physics courses as the function of their expectations, task value, and relative cost to complete physics tasks. We collected quantitative measures of their perceptions of physics, expectancy value, identity, and interest in physics in a pre/post survey study design. We analyzed data from an active learning Algebra-based physics course for three semesters between 2021-2023. This study will present how students' perceptions and utility value of physics shift throughout the course and impact their future career intentions. The shifts in perceptions will influence our projects' curricular development of strategies and activities addressing Pre-Health student's needs for future careers and reduce physics related anxiety.

(II-05 10:48 AM-11:00 AM) I Contributed Talk (12 Minutes) I Hackathons: An Activity Between Different Spanish High Schools that Encourages Developing Soft Skills and Much More

Presenting Author: Joel Garcia

Co-presenting Author | Edward Moriarty

Additional Author | Alicia López

The CIC-MIT Hackathó is a collaboration between Tech Projects, a Project Based Learning (PBL) course at CIC High School in Barcelona, Spain, and MIT Edgerton Center. In Tech Projects, students develop and complete an idea/project. Seeing the potential of student-initiated projects, we offered this experience to other local schools, beginning in 2019. Hackathó is an intensive 3-day event. High school participants work in teams to propose, construct, and complete a project. All teams learn and practice the phases of engineering design. High School teams are mentored by local Tech Projects graduates and MIT Edgerton Center mentors. Over the years, interest grows. The local department of education and the Universitat Politècnica de Catalunya contribute by giving space and helping train local mentors. A new course created within the industrial engineering degree trains future mentors with pedagogical tools and resources. Hackathon challenges youth to develop an engineering project in 3 days. From the conception of the idea to the construction of the definitive engineering, each team proposes trials and tests different prototypes. Is great challenge for young people and their teachers. Everyone – students, teachers, and mentors -- discovers learning while having fun. Even working under pressure!

Session IJ: PhysTEC: Preservice Teacher Recruitment

Location: Grand Ballroom C **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Adam LaMee

(IJ-01 10:00 AM-10:48 AM) | | How High School Teachers and Their Experiences Can Inform and Improve Recruitment of Pre-service Service Physics Teachers

Presenting Author: Jolene Johnson, University of Wisconsin River Falls

In this interactive workshop we will discuss ideas for supporting and partnering with current high school teachers to improve the recruitment of future physics teachers. In my career I have worked at all levels of physics education including teaching physics at low-income high schools during the pandemic. Teaching high school physics was by far the most challenging job I have ever had. Today's high school students often notice the challenging job their teachers have, and consequently very few students currently enter college with the intent of becoming high school science teachers. It is critically important that we support current high school teachers, not only to improve science education generally but specifically to recruit future science teachers. We must partner with high school teachers to hear about their challenges so that we can work together to address these challenges. Strong partnerships between high school and higher education also allows us to connect potential future teachers with pathways to teaching. I will discuss ideas and projects I am involved with such as STEP UP, PoLS-T, Visiting Scientists and others that are looking to build these partnerships to support and advocate for current teachers. We will also brainstorm ideas that you can implement at the local level.

Session IK: Remembering Charlie Holbrow

Location: Concourse Level - Commonwealth B **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Sean Robinson

Join us for a topical discussion to remember Charlie Holbrow.

Session IL: DEI Council Panel Discussion

Location: Lobby Level - Marina Ballroom I **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Catherine Herne

Since its formation at the start of 2023, the DEI Council has been working on several actions around increasing diversity, equity and inclusion in the AAPT community. In this session we briefly highlight some of the work we have done and discuss what we see as goals of the Council, based on the Roadmap developed by the DEI Task Force in 2022. The majority of the session will be discussion around what AAPT membership sees as the short- and long-term goals of the Council around professional development, meetings and events, and the AAPT Strategic Plan. We look forward to getting your input to help guide the direction of the Council.

Presenters:

Catherine Herne (DEI Council Chair), Mel Sabella (DEI Council Vice-Chair), Amy Robertson (DEI Council member), Mario Belloni (DEI Council member)

Session IM: Interactive: Effective Practices for Developing Scientific Reasoning

Location: Concourse Level - Commonwealth A **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Beverly Trina Cannon

(IM-01 10:00 AM-10:24 AM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Unleashing Physics Understanding Through Dimensional Analysis: An Instructors Guide

Presenting Author: Michael Peterson, Triangle Math and Sci Academy

Prepare to embark on an exciting jorney into the realm of theoretical physics with dimensional analysis! Dimensional analysis is an indispensable tool used by physicists, from astrophysics to the intricate world of condensed matter and high-energy. While commonly used to verify physics equations during problem-solving, its true power lies in simplifying complex physics using basic algebraic techniques. Join us for this session to discover how this method can improve your students' understanding of physics and empower them to craft mathematical expressions and bold hypotheses ready for experimental validation. According to student surveys, students feel that learning dimensional analysis is straightforward and leads to higher understanding and achievement. Research supports that embedding dimensional analysis within each unit of the physics curriculum results in a strong effect size on standardized physics tests. Session participants will not only grasp the essence of dimensional analysis but also learn how to seamlessly integrate this technique into their curriculum. After exploring a sample unit, we will craft our own lesson plans incorporating dimensional analysis. Get ready for your students' achievement to soar!

Session IN: PER: Impact of Peer Interactions on Learning and Persistence

Location: Lobby Level, Stone **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Ben Dreyfus

(IN-01 10:00 AM-10:12 AM) | Contributed Talk (12 Minutes) | Impacts of Inclusive Peer Mentoring Environments: Benefits, Challenges, & Relational Dynamics

Presenting Author: Kim Coble, San Francisco State University

Additional Author | Nick Provenzano, San Francisco State University

Additional Author | Cynthia Ibrahim, San Francisco State University

Additional Author | Bahar Amin, San Francisco State University

Additional Author | Joselyn Espinoza Lopez, San Francisco State University

Additional Author | Gabriel Munoz Zarazua, San Francisco State University

At a large, Hispanic-serving institution, the undergraduate Learning Assistant (LA) and Discussion Leader (DL) peer mentoring programs aim to transform traditionally lecture-based STEM courses to more active and inclusive learning environments, break down power hierarchies between students and instructors, and strengthen students' sense of belonging. Peer mentors (PMs) apply inclusive teaching techniques learned from a weekly pedagogy seminar they attend in class (LAs) or outside of the parent class (DLs). We iteratively coded and tallied frequency counts of emergent themes in 245 PM reflection essays, 17 PM interviews, and 400 student surveys to provide insight into challenges and benefits for PMs and perceived dynamics between faculty, LAs, and students. Consistent with the literature, PMs reported several benefits, such as becoming better learners, increased confidence, a greater appreciation for STEM teaching, enjoying helping others, having a supportive mentor, and a helpful, supportive STEM teaching community and pedagogy class environment. They also shared challenges and suggested improvements, such as wanting greater clarity in their role expectations. Students displayed a strengthened sense of belonging and improved content knowledge from interactions with PMs. These findings underscore the importance of these peer mentoring programs and provide a roadmap for their future development as we grow our programs.

(IN-02 10:12 AM-10:24 AM) | Contributed Talk (12 Minutes) | Peer recognition - Do First Impressions Last?

Presenting Author: Logan Kageorge, Brenau University

Additional Author | Meagan Sundstrom, Cornell University, Drexel University

Students' beliefs about how their peers recognize them as a strong science student are correlated with their persistence in science courses and careers. However, patterns of peer recognition can change over time. This study isolates the effect of time by analyzing student nominations of strong peers across a two-semester introductory physics course sequence, containing the same set of students and the same instructor in both semesters, at a mostly-women institution. We use a combination of social network analysis and qualitative methods to show that while many students receive similar levels of peer recognition over time, the most highly-nominated students exhibit some change between semesters even in this highly controlled setting. Here we delve deeper into the causes of these changes and challenge the generalizability of previous results that peer recognition depends solely on students' academic year.

(IN-03 10:24 AM-10:36 AM) | Contributed Talk (12 Minutes) | An Analytic Framework for Understanding Peer Coaches as Metacognitive Coaches

Presenting Author: Jonathan Kustina, University of New Hampshire

Additional Author | Dawn Meredith, University of New Hampshire

Peer coaches, such as Learning Assistants and Peer-Led Team Learning leaders, have been employed in introductory courses for over two decades to promote active learning of STEM content and problem solving. There have been numerous studies across content areas, which found that peer coaches improved learning outcomes for both their students and themselves. One subject that has received far less research attention is the connection between peer coaches and metacognition. To investigate if peer coaches could facilitate the metacognitive development of their students, we begin with an analytic framework for teacher knowledge that is used in preparing pre-service teachers. We then modify this framework to reflect the traditional work of peer coaches in their classes and their pedagogical training course, with metacognitive knowledge and regulation specified as the content areas. Using this framework, we analyze written data from the coaches' pedagogy course to assess their metacognitive competence. From this, we have found that peer coaches exhibit metacognitive competence as both learners and facilitators. We also find that they have a productive orientation towards facilitating metacognitive practices to their students. This data set serves as a strong positive indicator of their potential as metacognitive coaches.

This work was funded by NSF Grant 2013427

(IN-04 10:36 AM-10:48 AM) | Contributed Talk (12 Minutes) | Peer Mentorship as Counterspace

Presenting Author: Byron Drury, Massachusetts Institute of Technology

Additional Author | Ed Bertschinger

Additional Author | Michelle Tomasik

Additional Author | Joshua Wolfe

Peer mentorship can be a powerful tool in efforts to increase diversity, equity, inclusion, and belonging in physics. Mentors can serve as role models and provide academic and other support, including advice about classes, the hidden curriculum, how to find and prepare for research opportunities, and more. However, peer mentorship benefits not only the mentees but also the mentors. This work reports the results of surveying the experiences of mentors in a large peer mentorship program that provides academic and psychosocial support to undergraduates enrolled in physics classes at a research-intensive university. The results were analyzed as a function of ethnicity, race, gender, gender identity, and sexual orientation. Mentors of all identities reported feeling a stronger sense of belonging in the mentor community of practice than in their home departments or majors, and differences in sense of belonging between demographic groups were smaller in the mentor program than in other academic contexts. We argue that mentor programs at research intensive universities can provide a valuable counterspace for members of marginalized groups.

(IN-05 10:48 AM-11:00 AM) | Contributed Talk (12 Minutes) | Using Social Network Analysis to Understand Community Within an Introductory Physics Course for Engineers

Presenting Author: Jessica Nagasako, University Of Rochester

Additional Author | Geraldine Cochran, The Ohio State University Department of Physics

Social Network Analysis (SNA) provides a powerful way to assess social structures within communities. Brewe et al., (2015) found that centrality, a measure of a person's importance or role within a community, can predict student success as determined by their physics course grades. Bruun and Brewe (2013) found that social interactions correlated positively with physics conceptual inventory performance and physics course grade. We aimed to create a visual network of an introductory physics course's social structure. Using Python, we turned survey responses on students' interactions and group affiliations into a visual network of the class. Following Institutional Review Board (IRB) protocol, we replaced student names with randomly assigned numbers. From there we created an edge list that was used to create the visual network of the classroom. This network allowed us to identify students central to the network (most connected) and students isolated from the network (not connected to any other students). Our visual analysis of the network allowed us to identify students central to the network (most connected) and students isolated from the network (not connected). Our data supports that students in affinity-based professional groups are most central in the classroom network. Additionally, we found that there were no isolated students in the network.

Session IO: NANOGrav - 15 Years of Gravitational Wave Research I

Location: Concourse Level - Commonwealth C **Time:** 10–11 a.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Ann Schmiedekamp

(IO-01 10:00 AM-10:24 AM) | | Heralding the Multi-Messenger Universe: NANOGrav's Science Public Outreach Team

Presenting Author: Olivia Young, Rochester Institute of Technology/ NRAO

Astrophysics is at its core the study of "the big picture" of our universe. However, individual pixels of this big picture can be rendered incomprehensible if we remove them from the larger context, as is often the case with major scientific announcements and discoveries. We live in very exciting times for scientific discovery, and scientists must step up to ensure their science is easily understood by the public, especially by our youngest and most eager minds. NANOGrav's Science Public Outreach Team (SPOT) aims to do just that: bring the context needed to understand recent developments in our field to the public, especially K-12 classrooms. NANOGrav is part of a worldwide collaboration of scientists who recently found evidence for the passing of gravitational waves, tiny ripples in the fabric of reality, using dead stars called radio pulsars. However, understanding these exciting results requires a deeper understanding of many sub-fields in astronomy. What are gravitational waves and what causes them? What are radio pulsars and how can we use them to detect gravitational waves? NANOGrav scientists act as SPOT ambassadors and give presentations at K-12 schools, libraries, and other various public meetings to explain these connections.

(IO-02 10:24 AM-10:48 AM) | | A Back-of-the-Envelope Pulsar Timing Array Detector

Presenting Author: Michael Lam, SETI Institute

Pulsar timing array collaborations such as the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) have recently reported evidence for the background of low-frequency gravitational waves using an array of rapidly rotating, highly stable radio pulsars distributed across the galaxy. As an experiment covering a wide range of topics in physics that are highly technical, how can we mathematically rationalize our science to students with a basic understanding of physics? I will discuss some back-of-the-envelope math that justifies why ensembles of highly-stable radio pulsars - pulsar timing arrays - are viable for observing the gravitational waves in the nanohertz frequency range produced by sources such as inspiraling supermassive black hole binaries. These estimates have been used in lectures and workshops with good success in allowing students access to the physics and mathematics to perform calculations of their own.

Session JA: PER: Understanding and Using Generative AI in Physics Classes and Labs

Location: Harbor Level, Harbor I **Time:** 11 a.m.–12 p.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Jason Puchalla

(JA-01 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | Mapping the Literature Landscape of Artificial Intelligence in Physics Education Research: Preliminary insights.

Presenting Author: Amir Bralin, Purdue University

Additional Author | Amogh Sirnoorkar, Purdue University

Additional Author | N. Sanjay Rebello, Purdue University

We present a review of contemporary Artificial Intelligence (AI) literature in the context of physics education. The goal of this work is to gain insights into various AI methods (algorithms) employed in PER. We hope that such a characterization would help educators in making sense of the fast-evolving trends of AI research and development. In addition, we identify potential applications of AI in PER that have not been employed yet.
Supported in part by U.S. National Science Foundation grant 230065.

(JA-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | Leveraging Generative-AI to Support Students' Understanding About Physics Through Aanalogies

Presenting Author: N. Sanjay Rebello, Purdue University

Co-presenting Author | Amogh Sirnoorkar, Purdue University

Making sense of conceptual ideas through analogies is a common practice in physics. In this study, we explore the use of Generative-Artificial Intelligence (AI) in facilitating students' understanding of various physics concepts through analogical reasoning. We present preliminary insights from our empirical study where students articulated their understanding of physics laws in three ways: (i) in their own words, (ii) as though explaining to a second grader, and (iii) using scenarios of their choice. Students then compared their explanations with responses generated by ChatGPT for the same tasks, and made qualitative observations between the two sets of descriptions. We discuss the results in light of the affordances and constraints of using AI platforms in teaching and learning of physics.

(JA-03 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | ChatGPT-4's Ability to See Graphs and Reason About Them

Presenting Author: Giulia Polverini, Uppsala University

Additional Author | Bor Gregorcic, Uppsala University

Recently, ChatGPT-4 has become able to process image data as input, an ability that opens up a new range of possible applications in physics education, for both teachers and students. Our study aimed to investigate its performance in interpreting graphs, one of the most common representations used in physics. We tested ChatGPT's performance on the well-established Test of Understanding Graphs in Kinematics (TUG-K). We found that ChatGPT's performance is similar to those of students in terms of its average result on the test. However, it performs qualitatively differently from what we would expect from students; namely, its current limited ability to "see" graphs correctly deeply compromises its performance on the test, and thus its potential for use in physics teaching and learning.

Session JC: Three Perspectives on the Role of Computation in the Physics Class II

Location: Harbor Level, Harbor III **Time:** 11 a.m.–12 p.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Brandon Lunk

(JC-01 11:00 AM-11:24 AM) | | A Cognitive Model of Computational Modeling

Presenting Author: Brandon Lunk, Texas State University

What does it mean to learn computation in physics? One way to look at scientific computation is as a model or representation of physical processes. From this perspective, computation can serve as a pedagogical tool for learning physics much in the same way that we use graphs, diagrams, and algebra---and indeed computation can produce physical insights that other representations cannot. But this perspective leads us to consider cognitive models of thinking and learning that can give us insight into how we blend meanings between different representational systems—or, in the case of novices, how we fail to understand aspects of the representation. In this talk, I will outline computation's importance as a modeling tool and I will discuss how the cognitive model of Conceptual Blending can help us understand how students build meaning out of the code and can help us diagnose common failure points.

(JC-02 11:24 AM-11:48 AM) | | Discussion: Three perspectives on the role of computation

Presenting Author: Brandon Lunk, Texas State University

Discussion session following the three talks about the role of computation in the physics classroom.

Session JD: Student Learning in the Introductory Lab II

Location: Lobby Level - Marina Ballroom II **Time:** 11 a.m.–12 p.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Amin Bayat Barooni

(JD-01 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | Exploring Student Beliefs of Traditional Laboratory Coursework in Relation to Authentic Research

Presenting Author: Micah Kretchmer, University of Colorado Boulder/ JILA

Additional Author | Rachael L Merritt, University of Colorado Boulder/ JILA

Additional Author | Heather J Lewandowski, University of Colorado Boulder/ JILA

Undergraduate research is important for students. It can increase persistence in the major, feelings of belonging, and often enhances their qualitative and quantitative skills. However, there are barriers that prevent students' access to research experiences, from a limited number of positions to students' ability to have the time to participate. Course-Based Undergraduate Research Experiences (CUREs) act as a potential avenue to lower such barriers and equip students with some relevant research skills. Within STEM fields, physics has been identified as lacking CUREs, prompting our initiative to develop a CURE framework based on physics-specific opportunities and challenges. This framework will provide instructors with effective practice to develop their own CURE. As part of the framework development, we will be transforming our sophomore-level experimental physics lab into a CURE. Understanding students' perceptions of the connection between coursework and authentic research is needed to inform the framework and assess impacts from the course transformation. To this end, we probed student beliefs through writing assignments in the current traditional lab course, exploring parallels between coursework and authentic research elements such as discovery, agency, and failure. We will present the results from analysis of these assignments and discuss how these findings will be used to inform the CURE framework development.

(JD-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | Achieving Maximum Benefit in Introductory Physics Labs

Presenting Author: David Rishell, Vassar college

This presentation will describe the labs we do in the introductory calculus and non-calculus based physics courses at Vassar College. This talk is in 2 parts: 1) Concept reinforcement through familiarity with the phenomena that the text/lecture theories attempt to explain. By familiarizing themselves in the lab with the phenomena and providing structure to facilitate student "sensemaking" through several PER based approaches, such as workshop style, they acquire a stronger understanding of the concepts behind the phenomena. 2) We also have been working towards increasing student development of basic scientific skills (much needed after covid!) and good experimental design by striving to develop the students' epistemic agency; we strive to change their epistemic frame to the construction of knowledge from their experiments as opposed to confirmation or "hoops" framing (jumping through hoops!) and we try to include projects where the problem is ill-defined.

(JD-03 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | Qualitative Study of Student-created Engineering Design Projects

Presenting Author: Ravishankar Chatta Subramaniam, Purdue University, West Lafayette

Co-presenting Author | Amir Bralin , Purdue University, West Lafayette

Co-presenting Author | Carina M Rebello , Toronto Metropolitan University

Co-presenting Author | Jason W Morphew , Purdue University, West Lafayette

Co-presenting Author | N. Sanjay Rebello , Purdue University, West Lafayette

Engineering Design-based labs are a useful context to prepare students for STEM careers by engaging in science and engineering practices emphasized in NGSS and other reform documents. Research, however, shows that most students tend to employ 'trial and error' approaches rather than science knowledge to 'gadgeteer' solutions to engineering design tasks and do not necessarily display deep thinking of related science and mathematical concepts. To bridge this 'design science gap', we implemented an intervention in the lab component of a calculus-based physics course for future engineers. Student groups framed their own design problem and worked towards a solution in a multi-week laboratory. Students' written reports were analyzed qualitatively in four aspects: physics concepts, mathematical constructs, design thinking, and computational skills. We present the results of our study and implications for educators striving to provide opportunities for students to think deeply about science and engineering.

Supported in part by U.S National Science Foundation Grant 2021389

Session JE: Approaches to Introductory Physics Courses

Location: Lobby Level - Marina Ballroom III **Time:** 11 a.m.–12 p.m. **Date:** Wednesday, July 10, 2024 **Moderator:** Douglas Petkie

(JE-01 11:00 AM-11:12 AM) I Contributed Talk (12 Minutes) I SCALE-UP Physics and Sense of Belonging

Presenting Author: Dustin Hemphill, Penn State Erie

Physics has been taught in the SCALE-UP mode at Penn State Behrend since the spring of 2007. In this talk I will discuss our approach to SCALE-UP learning and share the results of a preliminary study of the role of a SCALE-UP classroom on student sense of belonging.

(JE-02 11:12 AM-11:24 AM) I Contributed Talk (12 Minutes) I Prevalence of AI-generated Language in Introductory Physics Lab Reports

Presenting Author: Kim Arvidsson, Schreiner University

The release of ChatGPT enabled students to have access to generative AI tools. Text with typical features of AI-generated human-like language, i.e., overly verbose and generic language that 'waffles' significantly started appearing in introductory physics lab reports in the Spring 2023 semester. To understand just how prevalent the use of generative AI has become among introductory physics students, about 800 lab reports were analyzed using two different AI-detection tools. About two thirds of the lab reports were submitted before ChatGPT was launched and one third were submitted after, which allowed for comparisons to be made. The results indicate that students are noticeably using generative AI to write physics lab reports. The AI-detection tools detect suspicious language, but the technical writing nature of physics lab reports complicates the interpretation of the returned AI-detection scores.

(JE-03 11:24 AM-11:36 AM) I Contributed Talk (12 Minutes) I The Pedagogical Approach to the Classical Treatment of Simple Harmonic Oscillators through Creation and Annihilation Operators

Presenting Author: Jason Tran, Georgetown University

Additional Author | Leanne Doughty, Georgetown University

Additional Author | James Freericks, Georgetown University

Students struggle with describing the motion of a damped harmonic oscillator due to the mysterious entrance of complex numbers and the often unsubstantiated command to "throw away" the imaginary part at the end of the calculation. Surprisingly, Born and Jordan inadvertently solved this pedagogical problem back in 1930 in their quantum mechanics textbook Elementare Quantenmechanik. Motivated by this approach, we show how complex numbers arise naturally in harmonic oscillators and how taking the real part at the end also arises naturally. The strategy is to convert the second-order equation of motion into two decoupled first-order equations of motion, which are mathematically much easier to solve. As an added bonus, this method also provides a beautiful introduction to the operator formalism for the quantum mechanical harmonic oscillator through creation and annihilation operators.

(JE-04 11:36 AM-11:48 AM) I Contributed Talk (12 Minutes) I Using Physics to Improve Science Literacy

Presenting Author: Aliyah Johnson, Alpharetta High School

Focusing on science (and math) literacy skills into physics instruction. Learn more about including relevant scientific articles, writing accurate and consise lab reports, or becoming comfortable discussing and/or presenting their findings orally help reinforce scientific literacy and communication skills.Incorporate pedogogical methods that encourage questioning and exploration. Discover ways to create a classroom culture that encourages curiosity, questioning, and exploration. What can happen to students' understanding and appreciation when they ask pertinient questions, challenge assumptions, and explore problems beyond the curriculum to foster a lifelong interest in physics and scientific inquiry. By implementing these strategies, educators can help students in physics class develop a solid foundation in scientific literacy comprehension and cultivate a deeper appreciation for the principles and applications of physics.

Session JF: PER: Student Understanding of Quantum Mechanics II

Location: Lobby Level - Marina Ballroom IV **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Kristin Oliver

(JF-01 11:00 AM-11:12 AM) I Contributed Talk (12 Minutes) I Case study of ChatGPT in an upper-level quantum physics class

Presenting Author: Jay Wang, University of Massachusetts Dartmouth

Adam Wang

We discuss the experience and lessons in a trial use of ChatGPT in an upper-level quantum mechanics class following a facilitated think-pair-share approach. ChatGPT was introduced to the class with intentional use as an aid in both conceptual and computational problem-solving activities. We gathered feedback and measured pre- and post-tests changes of students' beliefs on ChatGPT. We will present the results and observations pertaining to the capabilities of ChatGPT on learning of the subject matter, conceptual understanding, critical evaluation of AI tools, and potential attitude change of students.

(JF-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | Quantum Computing Conceptual Survey: Status and next steps

Presenting Author: Josephine Meyer, University of Colorado Boulder

Additional Author | Gina Passante, California State University Fullerton

Additional Author | Steven J Pollock, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

The Quantum Computing Conceptual Survey (QCCS) is a research-based assessment instrument under development targeting interdisciplinary introductory coursework in quantum computing. We highlight findings from our first two semesters of pilot data collection, including feedback from student and instructor interviews. We conclude with a brief discussion of the implications of our work for assessment in PER more broadly, specifically psychometric considerations associated with developing an assessment intended for students from heavily heterogeneous academic and disciplinary backgrounds in a rapidly-evolving field of study.

(JF-03 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | Assessing Student Understanding and Skills in Quantum Computing

Presenting Author: Beth Thacker, Texas Tech University

Additional Author | Jianlan Wang, Texas Tech University

Additional Author | Yuanlin Zhang, Texas Tech University

The revolutionary new field of Quantum Computing (QC) continues to gain attention in industry, academia and government in both research and education. At educational institutions, there is a proliferation of introductory courses at various academic levels signaling a growing interest and recognition of the significance of this field. A crucial aspect often overlooked is the development of research-based materials and pedagogical approaches to effectively teach quantum computing to diverse cohorts of learners across multiple disciplines. We present an empirical investigation using the multiple case study method. We report on a comparison two case studies, comparing students taught with and without a set of research-based mini-tutorials. The mini-tutorials are patterned after physics tutorials developed by various physics education research groups, however, they are administered in class and are shorter, designed to be done in 20-30 minutes, and focus on one important concept, skill or topic covered in class. The research methodology involves conducting interviews with students, analyzing the interview transcripts to identify students' strengths and difficulties, especially on specific topics covered by the mini-tutorials, and comparing the two cases of students taught with and without the mini-tutorials.

(JF-04 11:36 AM-11:48 AM) | Contributed Talk (12 Minutes) | Instructors' Views on a Flexible Assessment Design

Presenting Author: Jesse Kruse, University of Colorado Boulder

Additional Author | Bethany Wilcox, University of Colorado Boulder

Flexible assessments are distinct from standard research-based assessments like the Force Concept Inventory in that the items and the item ordering may differ between administrations. Our group has been developing a flexible assessment for upper-level undergraduate quantum mechanics called the Quantum Physics Assessment (QuPA) to address the lack of consensus on what can/should be taught in an undergraduate quantum course. This assessment will exist on a web platform where instructors can select topics they want to assess and other testing parameters. In Fall 2023, we conducted 34 interviews with faculty from institutions across the U.S. asking them about their experience with assessments, what they would improve, and what feedback would be useful. This paper will present the theory and motivation for flexible assessment of quantum mechanics proficiency, discuss our interview protocol, and summarize the general views of the instructors.

Session JG: PER: Student's Perspectives

Location: Harbor Level - Lewis **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Colin Fredericks

(JG-01 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | Recognizing the Diverse Forms of Expertise that Students Bring to Change Work

Presenting Author: Robert Dalka, University of Maryland, College Park

Additional Author | Chandra Turpen, University of Maryland, College Park

Students are partnered with in many different cases of physics departmental change projects, both in course transformation and in larger programmatic change. Students bring diverse forms of expertise and continue to develop their skills as part of these teams. One form of this expertise is tied to their lived experiences within physics programs and their unique perspectives that are not accessible to faculty members. While this form of expertise plays an important role in developing authentic change projects to address students' needs, framing student expertise only through the "student perspective" limits their ability to bring in other forms of expertise such as community activism, work experiences, and group work skills. In this talk, we will share how this plays out within various change team settings through student and faculty interviews and observations of team meetings. We will illustrate the ways in which what counts as students' expertise is narrowed, but also how it is expanded, within team processes. Through identifying the impacts on the change efforts pursued, we will identify how teams can recognize the variety of skills that students bring and how students can continue to grow in their expertise.

(JG-02 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | Students' Perception of the Inclusiveness of Learning Environment in Introductory Physics Courses

Presenting Author: Yangqiuting Li, Oregon State University

Additional Author | Noah Leibnitz, Oregon State University

Additional Author | Rebecka Tumblin, Oregon State University

Prior studies have shown that students' perception of the inclusiveness of the learning environment statistically significantly predicts their academic and motivational outcomes in physics classes. In this study, we investigated students' experiences in introductory physics courses and how these experiences shape their perceptions of the inclusiveness of the learning environment. The findings can be useful in creating equitable and inclusive learning environments in which all students can thrive.

(JG-03 11:36 AM-11:48 AM) | Contributed Talk (12 Minutes) | Undergraduates Speak Out on Their Experience of Reflective Journaling in Physics and Astronomy Labs

Presenting Author: Niah Freeman, San Francisco State University

Co-presenting Author | Kim Coble, San Francisco State University

Additional Author | Ana M Barrera, California State University Dominguez Hills

San Francisco State University, a hispanic serving institution, is home of the Alma Project, which was created to promote and affirm students identities in order to increase inclusivity in STEM. It started in 2018 in supplemental instruction classes, and was later implemented in all introductory physics and astronomy labs. The Alma project uses reflective journaling in these classes in order to center students' experiences in STEM. Iterative thematic coding was used to analyze surveys taken by students on how the ALMA reflective journaling influenced their personal experiences and learning in the classroom, and the effect it had on the overall classroom environment. We've gathered over 3000 survey responses from Spring 2020 to Spring 2023 in our conceptual astronomy, conceptual physics, general physics, and calculus-based physics courses. We've established 42 themes from our surveys, organized in categories of negatives, positives, and implementation. The results of the surveys demonstrated an overwhelming positive experience from the students. Major examples include relieving stress, understanding themselves better, enhancing a sense of purpose for their future, and feeling a connection to their classmates. The majority of the responses that were coded as negative were that students felt neutral or that journaling had no impact on their experience in the classroom.

(JG-04 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | Using Mixed Methods to Investigate a Physics Undergraduate Student's Self-Efficacy

Presenting Author: Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Self-efficacy, one's confidence in their ability to complete a task, has been shown to be a predictor of students' science performance and persistence. Traditionally, self-efficacy has been studied at the beginning and end of the semester to gain insights into the impacts on students' self-efficacy, which may be influenced by one's memory. To reduce the influence of memory, we designed an explanatory sequential mixed methods approach to capture moments from daily life that may threaten or support one's self-efficacy closer to when they occur. To capture such moments, we paired the Experience Sampling Method (ESM) with individualized daily journal reflections. This method allowed us to capture the impact of a breadth of undergraduate experiences, such as coursework, being a learning assistant, or working as an undergraduate researcher in a research lab, on one's self-efficacy. In this talk, we will present a case study examining how participating in these different activities influenced a physics undergraduate student's self-efficacy across several semesters.

Session JH: PER: Redesigning Legacy Assessment Tools

Location: Mezzanine Level - Douglass **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Robin Bjorkquist

(JH-01 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | Redesigning Legacy Conceptual Inventories: Using Evidence Centered Design to Develop Valid, Equitable, and Flexible Items for Conceptual Understanding of Kinematics and Dynamics in Introductory Physics

Presenting Author: Rachel Henderson, Michigan State University

Additional Author | John Stewart, West Virginia University

Additional Author | Gay Stewart, West Virginia University

Additional Author | Andrew Heckler, Ohio State University

Commonly used legacy instruments, such as the Force Concept Inventory (FCI), have shown some serious flaws including substantial psychometric problems and demographic biases which make them inaccurate for some underrepresented student populations. Even with these flaws, these instruments have been vital to the development of Physics Education Research (PER) as a discipline; however, while the teaching of physics has evolved, the formative assessments researchers, instructors and, more broadly, physics departments use to evaluate their classrooms have not. In this talk, we will discuss the project goals and development strategy of our new NSF award (#2235518) intended to design a set of valid, fair, and flexible tool assessing conceptual understanding of kinematics and dynamics for introductory physics courses. Constructed with Evidence Centered Design, the new assessment items will be grounded in learning and measurement theory while based on a construct-centered and community-based approach. The flexible instrument, the Kinematics and Dynamics Assessment, will include multiple scales measuring foundational topics within kinematics and dynamics organized into subscales which instructors can utilize to build their own classroom assessment. The library of items will be extensively validated to ensure superior psychometric properties and instrumental fairness for women, underrepresented minority students, and first-generation college students.

This work is supported by the National Science Foundation (DUE-2235518, DUE-2235595, and DUE-2235681).

(JH-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | Redesigning Legacy Conceptual Inventories: DIF Analysis for 1-D Kinematic Items

Presenting Author: Brett Ballard, West Virginia University

In the ongoing effort to develop a new concept inventory of Newtonian mechanics, context neutral 1-D kinematic items were given to students at three universities. An analysis of differential item functioning across gender, race/ethnicity, and first generation college student status was conducted using both non-IRT based methods, such as the Mantel-Haenszel Test and SIBTEST, and IRT based methods, such as Lord's Test and Raju's Test. A comparison of the results for these various analyses are presented. Several items test significantly for differential item functioning even when presented in a neutral context. Concurrently, an analysis of differential distractor functioning across gender, race/ethnicity, and first generation college student status was conducted using group-specific multinomial log-linear regression. Similarly, several items tested significantly for differential distractor functioning; their nominal item response curves were plotted.

(JH-03 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | Redesigning Legacy Conceptual Inventories: Initial Results from the One-Dimensional Kinematics Subscale

Presenting Author: John Stewart, West Virginia University

This talk is part of a project (NSF award #2235518) to develop replacement instruments for the Force Concept Inventory (FCI) and the Force and Motion Conceptual Evaluation (FMCE). The project seeks to identify and develop subscales representing different dimensions of a Newtonian Force Concept. The first scale to be developed measures a knowledge of one-dimensional kinematics. More than 40 items were piloted and tested at 3 large research universities in the Spring 2024 semester producing over 2000 student responses. Both qualitative and quantitative validation is underway. This talk will discuss lessons learned in the validation process and present examples of both bad and good kinematics items. Results of quantitative validation will be summarized. This project ultimately will produce a short FCI/FMCE replacement scale with cross-norming data to the original instrument.

(JH-04 11:36 AM-11:48 AM) | Contributed Talk (12 Minutes) | The Role of Cognitive Inteviews in Redesigning Legacy Conceptual Inventories

Presenting Author: Elaine Christman, West Virginia University

Additional Author | John C. Stewart, West Virginia University

A project (NSF award #2235518) is underway to use evidence-centered design to create a replacement for the Force Concept Inventory (FCI) and Force and Motion Conceptual Evaluation (FMCE) comprising subscales developed with input from the physics education community. We have begun to collect qualitative data on the first of these subscales, covering concepts in one-dimensional kinematics, through three-step test interviews in which we ask students to think aloud while solving problems, give them retrospective probes intended to fill in apparent gaps in observed behavior and stated thought processes, and then elicit student opinions about the problems. In this talk, we'll share how the rich data collected in these interviews are being used to revise and validate items, as well as what we've learned about best practices in writing items and developing figures based on the sometimes surprising ways students approach these problems.

Session JI: Supporting Learners with Disabilities

Location: Grand Ballroom D **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Martin Kamela

(JI-01 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | Supporting Disabled Physics Learners: Identifying Enabling, Mitigating, and Disabling Practices

Presenting Author: Erin Scanlon, University of Connecticut

Additional Author | Emily Tarconish, University of Illinois - Urbana/Champaign

Additional Author | Allison Lombardi, University of Connecticut

Additional Author | Jacquelyn J Chini, University of Central Florida

Faculty have a significant stake and role to play in students' overall success within higher education environments. It is important for faculty to be sensitive to the numerous ways in which their actions can create, lower, or eradicate barriers to access and participation for students. In this presentation we will discuss one method instructors can utilize to consider variations in student needs, abilities, and interests when designing courses, delivering course content, and assessing learning. First, we will introduce the Variations Planning Tool (VPT) as a mechanism for instructors to critically examine who they are privileging and who they are simultaneously taxing based on the instructional practices. This analysis supports instructors to identify barriers to access and participation within their instruction. Finally, we will provide examples of enabling, mitigating, and disabling instructional strategies as well as examples of reformed practices from the COVID-19 pandemic.

(JI-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | Positive Conceptions of Impairment Espoused by Physics Mentors Who Work with Disabled Students

Presenting Author: Constance Doty, University of Central Florida

Additional Author | Erin M Scanlon, University of Connecticut at Avery Point

Additional Author | Dan P Oleynik, University of Central Florida

Additional Author | Jacquelyn J Chini, University of Central Florida

Physics mentors' interactions with disabled physics mentees may be shaped by their preconceived ideas about disability and the interaction of specific impairments with physics learning and research experiences. Physics mentors' preconceptions might negatively impact students' learning and research experiences through mechanisms such as limiting opportunities or stereotype threat. After teaching or mentoring a student with a disability, faculty members may develop positive conceptions about the impairment experienced by the disabled mentee. We interviewed eight physics mentors about their experience teaching or mentoring disabled students. In this comparative case study, guided by the affirmative model of disability (i.e., conception that impairments can negatively and positively impact a disabled individual's well-being) we use thematic analysis to find examples of positive conceptions of impairments experienced by students with disabilities as described by mentors. We discuss the implications of our findings for teaching and mentoring.

(JI-03 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | A Phenomenology of Neurodivergent Physics Students' Identity Development

Presenting Author: Liam McDermott, Rutgers University

Additional Author | Nazeer A. Mosley, Rutgers University

Additional Author | Geraldine L. Cochran, The Ohio State University

Over the past four years, our team has studied the essence of what it means to be a neurodivergent physics student, including undergraduates, post-baccalaureates, and graduate students. In this talk, we present themes from the narratives of 15 neurodivergent individuals whom we interviewed. We explore how these students navigate through the neurotypical-normative environment of academia being neurodivergent - an identity marked by non-normative cognition, perception, and behavior. By centering the voices of neurodivergent students, we shed light on the unique struggles, triumphs, and identity negotiations inherent to their educational journey. In doing this, we share stories of both neurodivergent students' experiences with marginalization and ableist violence, and their experiences of neurodivergent joy and pride. The findings contribute to a deeper understanding of the intersection between neurodiversity and physics identity, offering insights that can inform more inclusive practices within physics education.

(JI-04 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | WORLDLY Recognized Mnemonic Technique (Vowels: Mathematical Operations) for Memory Compensation

Presenting Author: Shannon Schunicht, Texas A&M University

Mr. Schunicht is a Military veteran who recovered from an unusual fatal mid-air plane crash. The accident involved another plane landing on top of Mr. Schunicht's plane while performing a long low approachnan an unconctrolled airport Draughton-Miller) in Temple, TX. After being hospitalized for more than six months, he developed medical ambitions. A VA vocational rehabilitation counselor suggested the sudy of Microbiology at Tx A&M University ('94 BA Biology and BS Microbiology). This was particullarly diffcult after being in a three-week coma; however physics (PHY 201 and 202) were required for graduation from Texas A&M, This meant he had to memorize countless complex formulas, most were completely new to him. To compensate, Mr.Schunicht developed a mnemonic technique (Vowels: Mathematical Operations) in the spirit of Dr. Seuss (Theodor Seuss Geisel). Examples include an acronym for The Quadratic Formula with ADDITIONAL CONSONANTS (exCePT i buiLD rabbiTS 4 caTS oN 2 HaTS). While lecturing in Syracuse, he was televised (2:30) by WTVH and able to share www.mnemonicwriting.com Using this technique, any formula can be algebraically manipulated into memorable word(s) for recollected ease. The potential this technique has with Western languages is remarkable, whereas Eastern characters have yet to be explored and remain limitless as $\Delta X => 0$! Now, recognized by Marquis' Who's Who as a lifetime achiever after being WORLDLY selected for more than 20 years. Cover/Centerfold Marquis' Insight magazine => select Marquis' logo at bottom of mnemonicwriting.com

Session JK: Remembering Priscilla Laws

Location: Commonwealth A **Sponsor:** AAPT **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Frances Poodry

Join us for a topical discussion to remember Priscilla Laws.

Session JM: Implementing Innovative Stratigies

Location: Concourse Level - Commonwealth A **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Rudra Kafle

(JM-01 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | Introductory Physics for the Built Environment

Presenting Author: Jeremy Wachter, wachterj@wit.edu

What physics matters most for designing and constructing the structures we inhabit? Motivated by this question, I discuss the development of a one-semester, lecture/lab, introductory physics course to benefit students majoring in the "built environment": architecture, interior design, and industrial design. The course incorporates more physics of light, sound, and heat than is typical for first-semester physics, and explores certain topics (such as reverberation or heat transfer) to greater conceptual depth. I describe the outline and interdisciplinary connections of the class and give examples of hands-on in-class activities and laboratories.

(JM-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | A Survey of Conceptual Modern Physics Courses in U.S. Colleges and Universities Intended for First-year Non-science Majors

Presenting Author: Ryan Sayer, Bemidji State University

Additional Author | Annie C Courtemanche, Bemidji State University

In colleges and universities in the U.S., modern physics courses (i.e., courses focused on quantum mechanics, relativity, elementary particles and/or cosmology) are typically targeted for majors in physics or other STEM fields and usually require prior knowledge of classical physics and calculus. However, some colleges and universities also offer modern physics courses to first-year students who are not planning to major in STEM-related fields. These introductory modern physics courses generally receive less attention in the literature of PER. However, they present a unique opportunity to educate our future leaders and teachers about contemporary physics topics that often get overlooked in general introductory physics courses, giving them a deeper perspective of everyday technology and current physics research. In this study, we conducted an extensive review of the course catalogs of all four-year degree-granting U.S. institutions of higher learning and have compiled a list of modern physics courses targeted for non-science majors. We identified statistical information about the institutions that offer these courses, such as their Carnegie classifications, enrollment numbers, and locations. We also identified common features of physics departments that tend to offer these courses, such as their sizes and program offerings.

(JM-03 11:36 AM-11:48 AM) | Contributed Talk (12 Minutes) | Improving and Transitioning a Student-centered Physics and Society Course between Faculty: A Research-practice Case Study

Presenting Author: Carolyn Sealfon, Minerva University and Ronin Institute

Co-presenting Author | Garrick Burron, University of Toronto

Additional Author | Pekka Sinervo, C.M., University of Toronto

We discuss the design and implementation of a Physical Science in Contemporary Society course, a 40-student senior-level physics course at the University of Toronto that encourages physics students to explore how physics and society influence each other. Student-centered course design elements included ungrading, student-led active-learning instruction, and student-defined final projects. A different instructor taught each iteration of the course with a PhD student in the Faculty of Education acting as a "critical friend" to bridge the handover of the course and to analyze course elements using a self-study research approach. Features of this successful case study suggest promising approaches to support student-centered innovations and to transition active-learning course designs between faculty members.

(JM-04 11:36 AM-11:48 AM) | Contributed Talk (12 Minutes) | Development and Assessment of Adaptive Game-Based Learning Using Hexad

Presenting Author: Razan Hamed, Purdue University

Co-presenting Author | N. Sanjay Rebello, Purdue University

One of the main objectives of Game-Based Learning is to engage students in formal and informal educational settings using games and play. However, research has shown that some educational games were not very effective in engaging students as intended, and in some cases, made no difference. One of the reasons behind this issue is that many educational games follow the 'one size fits all' approach, which is not adaptive nor considerate of the different educational needs of the students. Therefore, game-based learning is shifting towards adaptivity and personalization of educational games that are designed to fit students' interests and their psychological and pedagogical needs. In order to design and develop adaptive educational games, several measurement tools have been created and validated. This talk will discuss one of the most recent measurement tools (Hexad) and its implications on designing and developing an educational physics video game for non-physics majors.

Session JN: PER: Ideas, Reasoning, and Problem Solving

Location: Lobby Level, Stone **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** Ben Dreyfus

(JN-01 11:00 AM-11:12 AM) | Contributed Talk (12 Minutes) | The Importance of Gesture in Sensemaking in Physics, Part 1

Presenting Author: David Brookes, California State University, Chico

Additional Author | Yuehai Yang, Oregon Institute of Technology

Additional Author | Heather J Brookes, Stellenbosch University

In this talk we put forward a theoretical rationale for how students make sense of ideas in physics. Reasoning and problem-solving in physics involves the coordination of multiple representations. In this process, gesture sits at the intersection of social, material, and cognitive accounts of student reasoning. Representations are made up of signs that signify physical objects and processes. Students need to make sense of these signs and what they signify. This sensemaking involves building a sensory-motor simulation of reality that is activated when processing and understanding each sign. We propose that the bridge between the sign and the signified is built through representational gesture (both iconic and metaphorical) and that it is through this process of gesturing that students in an active learning physics class engage in "making sense," building a connected perceptual symbol that they can then use both externally (through speech and writing) and internally (in the brain) to perform computation and inference that leads to further knowledge and understanding. We will discuss the implications of this idea for both the design of learning environments and the necessity of active learning environments where space and time are offered for students to engage in making and negotiating meaning.

(JN-02 11:12 AM-11:24 AM) | Contributed Talk (12 Minutes) | The Importance of Gesture in Sensemaking in Physics, Part 2

Presenting Author: Yuehai Yang, Oregon Institute of Technology

Additional Author | David T Brookes, California State University, Chico

Additional Author | Heather J Brookes, Stellenbosch University

We hypothesize that gesture is a crucial element in physics students' sensemaking. We collected our data from videos of 10 student groups who were actively engaged in Investigative Science Learning Environment (ISLE) activities at Florida International University. We predicted that students' use of representational gestures (gestures that represent physical or metaphorical objects or processes) should increase during critical sense-making episodes. Our analysis showed that students' gesturing time percentage and gesture rates during their conversations were much higher when students were having "sensemaking" discussions than when they were having other conversations, such as "logistics" or "off topic". This was found to be true at both group level and individual level. Among all types of gesturing, the use of representational gestures dominated when they were doing "sensemaking". This work can potentially help instructors to identify the moments of deep and productive learning. Instructors can then foster student learning by providing resources and environments to help students elaborate and negotiate their ideas collaboratively, using multiple modalities, including gesture.

(JN-03 11:24 AM-11:36 AM) | Contributed Talk (12 Minutes) | Homework Corrections in Upper-division Physics Courses: Student and Instructor Motivations

Presenting Author: Molly Griston, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

It is widely recognized that problem solving is a vital skill for physics students to learn. One element of expert-like problem solving is reflecting on one's solution and iterating as necessary. In upper-division physics courses, students are typically given ample opportunity to practice problem solving in the form of homework; however, there is often not much structure in place for reflection and iteration. One avenue for formalizing this revision process is homework corrections, in which students earn points back for submitting corrections to their homework. While potential benefits of homework corrections are apparent, instructors have also voiced concerns, and further research is necessary to understand if and how homework corrections can be implemented effectively. As part of a larger study analyzing the implementation of and participation in homework corrections, we present instructor motivations for offering homework corrections and student motivations for engaging with them.

Session JO: NANOGrav - 15 years of Gravitational Wave Research II

Location: Lobby Level - Otis **Time:** 11 a.m.–12 p.m **Date:** Wednesday, July 10, 2024 **Moderator:** TBA

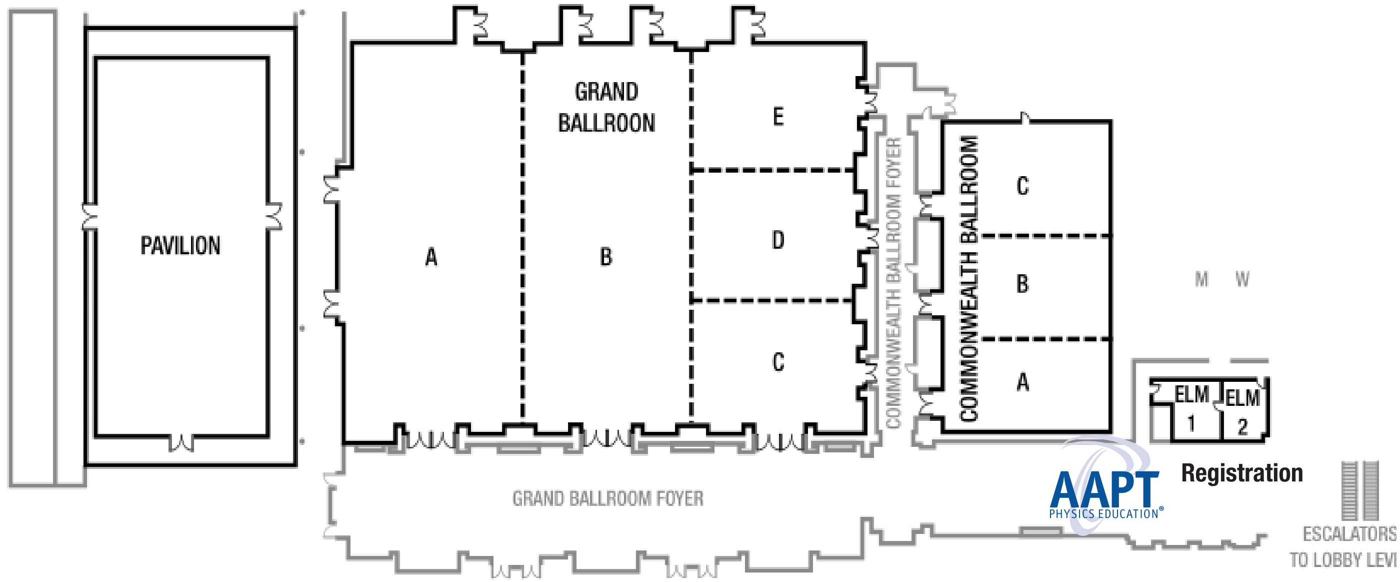
(JO-01 11:00 AM-11:24 AM) | | Unveiling the Cosmic Symphony: Insights into the Universe from NANOGRAV'S 15-Year Results

Presenting Author: Lankeswar Dey, West Virginia University

Gravitational waves (GWs), ripples in the fabric of spacetime, offer us a unique window into the universe, revealing objects and phenomena invisible to light. Recently, we have found evidence for the presence of a low-frequency (nanohertz) GW background in the NANOGrav 15-year dataset. However, the origin of the background still remains elusive. While a population of supermassive black hole binaries is considered the most promising candidate for the source of the GW background, the observed background can also be explained by other phenomena in our universe, such as cosmological phase transitions, inflation, and cosmic strings. In this presentation, I will review various potential sources for the detected GW background, discuss what the NANOGrav 15-year results can reveal about the population of supermassive black hole binaries in our universe, and explore how we can identify the true source of the background. All of these efforts are expected to pave the way for the inauguration of persistent multi-messenger nanohertz GW astronomy in the near future.
https://iopscience.iop.org/collections/apjl-230623-245-Focus-on-NANOGrav-15-year

Floor Plans at Westin Boston Seaport District

CONCOURSE LEVEL



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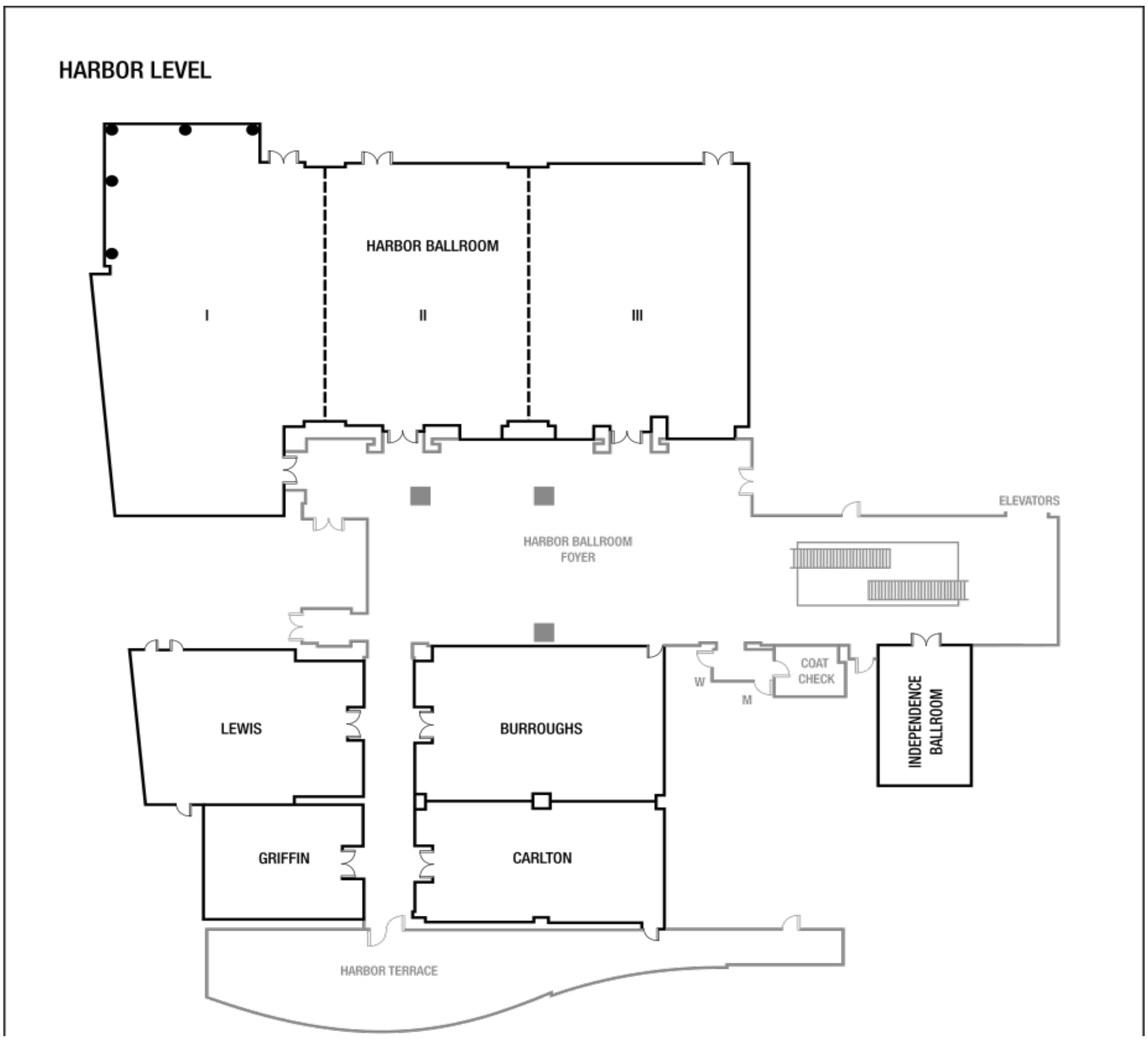

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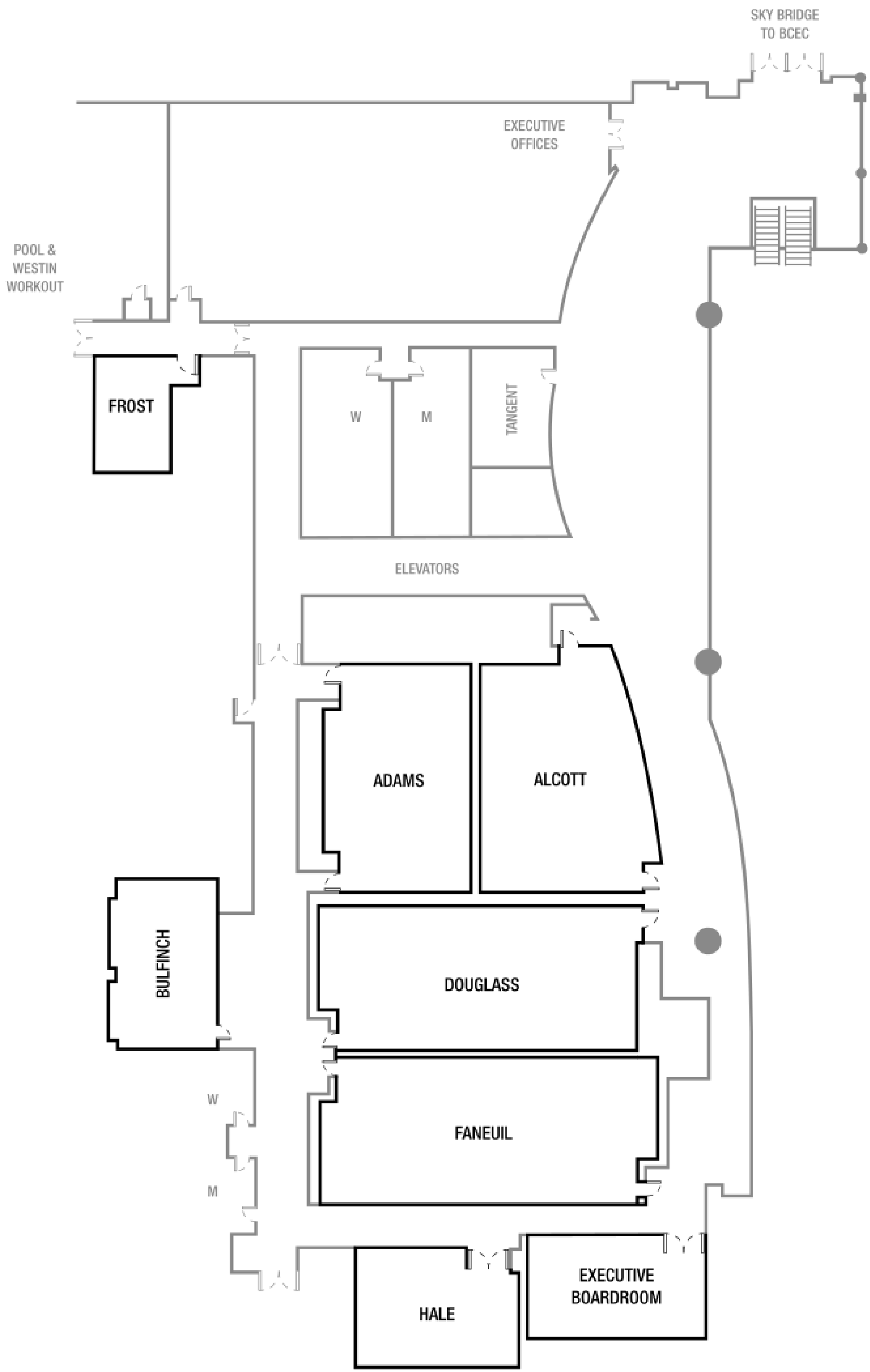

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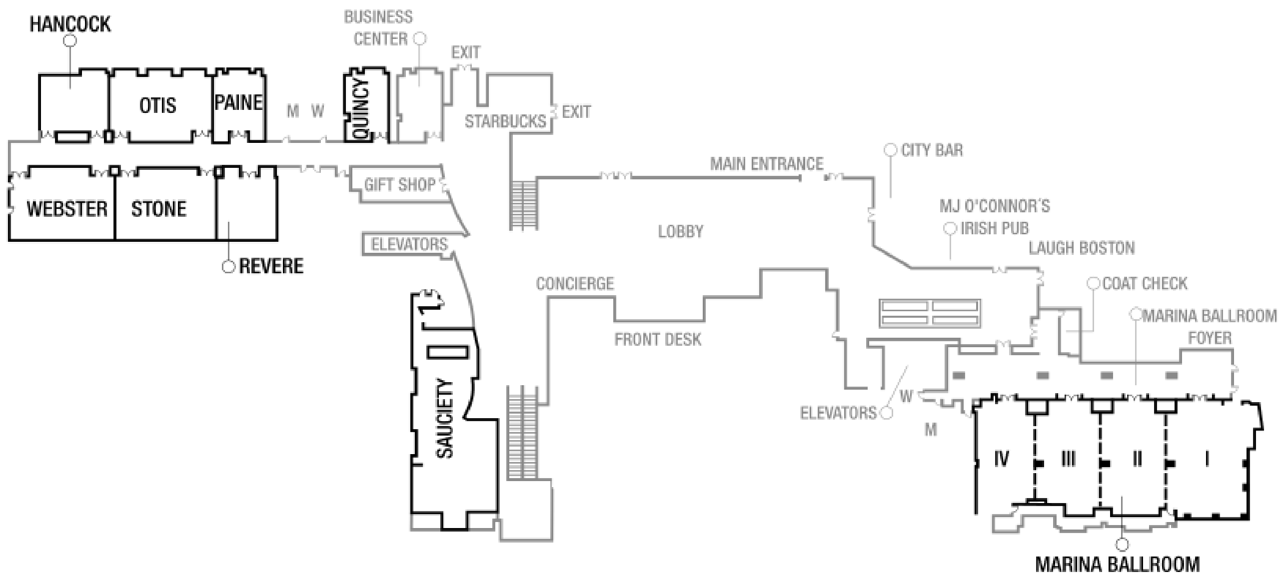

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