AAPT
PHYSICS EDUCATION®

AAPT 2023 SUMMER MEETING

15-19 JULY

Sacramento, CA

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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:

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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 **#aaptsm23**. 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 Grand Rapids area. We look forward to connecting with you!

Facebook: facebook.com/AAPTHQ
Twitter: twitter.com/AAPTHQ
Pinterest: pinterest.com/AAPTHQ

Committee Meetings

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

Saturday, July 15

Investment Advisory Committee	7:30–8:30 p.m.	Meeting Room 01

Sunday, July 16

Meetings Locations Committee	8–8:45 a.m.	Meeting Room 03
Nominating Committee I	8–8:45 a.m.	Sheraton–Bataglieri
Publications Committee	8–8:45 a.m.	Sheraton–Bevis
MPC and AMP 24	8–9 a.m.	Meeting Room 04
Resource Letters Committee	3:30–4:30 p.m.	Meeting Room 01
ALPhA Open Meeting	3:30–4:30 p.m.	Meeting Room 02
Area Committee Leadership (Programs Committee I)	4:30–5:30 p.m.	Meeting Room 03
Section Officers and Representatives	4:30–5:30 p.m.	Meeting Room 04

Monday, July 17

Graduate Education in Physics *	7:45–8:45 a.m.	Sheraton–Carr
History and Philosophy in Physics *	7:45–8:45 a.m.	Sheraton–Compagno
Laboratories Committee *	7:45–8:45 a.m.	Sheraton–Bevis
Physics in Undergrad. Educ. Committee *	7:45–8:45 a.m.	Sheraton–Tofanelli
Educational Technologies *	12:30–1:30 p.m.	Ballroom A09
Teacher Preparation *	12:30–1:30 p.m.	Ballroom A05
Interests of Senior Physicists *	12:30–1:30 p.m.	Ballroom A04
Women in Physics *	12:30–1:30 p.m.	Ballroom A07
Finance Committee	12:30–1:30 p.m.	Ballroom A03
Lotze Scholarship Committee	12:30–1:30 p.m.	Ballroom A06
PIRA	12:30–1:30 p.m.	Ballroom A11
Review Board	12:30–1:30 p.m.	Ballroom A08
Awards Committee	5:30–6:30 p.m.	Ballroom A04
Contemporary Physics Committee *	5:30–6:30 p.m.	Ballroom A03
International Physics Educ. Committee *	5:30–6:30 p.m.	Ballroom A07
Physics in Pre-High School Education *	5:30–6:30 p.m.	Ballroom A06
Professional Concerns Committee *	5:30–6:30 p.m.	Ballroom A05
Science Education for the Public *	5:30–6:30 p.m.	Ballroom A10
PERTG Town Hall *	5:30–6:30 p.m.	Ballroom A09
Physics in Two-Year Colleges *	5:30–6:30 p.m.	Ballroom A08

Tuesday, July 18

PTRA Oversight Committee	7:45–8:45 a.m.	Meeting Room 09
Membership and Benefits Committee	8–8:45 a.m.	Meeting Room 04
Apparatus Committee *	6:30–7:30 p.m.	Ballroom A06
Diversity in Physics Committee *	6:30–7:30 p.m.	Ballroom A07
Physics in High Schools *	6:30–7:30 p.m.	Ballroom A02
Research in Physics Education *	6:30–7:30 p.m.	Ballroom A03
Space Science and Astronomy *	6:30–7:30 p.m.	Ballroom A05

Wednesday, July 19

Area Committee Leadership (Programs Committee II)	8–9 a.m.	Meeting Room 12/13
Governance Structure Committee	8–9 a.m.	Sheraton–Bevis
PER Leadership Organizing Council	8–9 a.m.	Sheraton–Bataglieri
Venture Fund Review Committee	8–9 a.m.	Meeting Room 14/15

Jeffrey Bennett to Receive 2023 Klopsteg Memorial Lecture Award

Jeffrey Bennett

Jeffrey Bennett, astronomer, teacher, and writer, is the 2023 recipient of the Klopsteg Memorial Lecture Award. This award recognizes educators who have made notable and creative contributions to the teaching of physics.

Regarding his selection to receive the 2023 Klopsteg Award Bennett said, "I'm very honored to receive this award, especially since it comes from the American Association of Physics Teachers, which represents a group of outstanding educators who share my passion for using physics — and science in general — to help us create a better and more just world for everyone."

Bennett received his B.A. in Biophysics from the University of California at San Diego and an M.S. and Ph.D. in Astrophysics from the University of Colorado at Boulder. Specializing in mathematics and science education, he writes for and speaks to audiences ranging from elementary school children to university faculty.

For more than 30 years, Bennett has successfully advanced the cause of public understanding of physics. Key achievements include:

- Serving as the first "Visiting Senior Scientist" at NASA Headquarters whose focus was specifically on education and outreach. In this role, he launched a transformative effort at NASA that vastly expanded public outreach by scientists engaged in astrophysics missions and research.
- Creating the concept for a new and innovative type of scale model solar system exhibit, first at the University of Colorado and then with the Voyage scale model solar system (for which he served as co-PI), the first permanent installation on the U.S. National Mall in Washington, DC to be focused specifically on science education. The Voyage model depicts the Sun, the planets, and the distances between them on a scale of 1 to 10 billion, providing visitors an accurate sense of the vastness of our solar system, a unique perspective on the beauty and fragility of our home planet, and the inspirational message embodied in the fact that our species has managed to learn so much about other worlds. Dr. Bennett continues to work with the Voyage National Program (voyagesolarsystem.org) to spread Voyage "Mark II" models around the nation.
- Leading creation of the free Totality app (bigkidscience.com/eclipse/), which helps people plan for upcoming solar eclipses and learn eclipse science. He is currently in the process of donating ownership of the app to the American Astronomical Society, through which it is likely to be used by millions of people for the upcoming 2023 annular and 2024 total solar eclipses.

Pathway to a Post-Global Warming Future — Teaching a Scary Topic with Inspiration, Not (Only) Fear

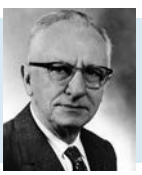
Tuesday, July 18

4–5 p.m.

Ballroom A01

Pathway to a Post-Global Warming Future — Teaching a Scary Topic with Inspiration, Not (Only) Fear

Today's students often express despair when it comes to the topic of climate change, which is unsurprising given that the media often portrays our climate future as a choice between bleak and bleaker. But it doesn't have to be that way, because if we understand the science behind global warming, then we can also see pathways to its solution. In this presentation, I'll show you how I try to approach the topic "with inspiration, not (only) fear," by providing simple ways to discuss global warming science, consequences, and solutions. In this way, students (and adults!) can begin to envision the possibility of creating a "post-global warming" future within their own lifetimes, meaning a future in which the threat of global warming will have been relegated to the history books. While much of the science will be familiar to physics teachers, I hope you will take away a few concrete ideas to help you in your own teaching.



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.

Alice Flarend to Receive 2023 Paul W. Zitzewitz Excellence in K-12 Teaching Award

Alice Flarend

The 2023 Paul Zitzewitz Excellence in K-12 Physics Teaching Award winner is Alice Flarend, physics teacher at Bellwood-Antis High School, Bellwood, PA This award is in recognition for contributions to pre-college physics teaching and awardees are chosen for their extraordinary accomplishments in communicating the excitement of physics to their students.

The Awards committee citation for her award is as follows: "For exemplary teaching at the high school level and development of innovative instruction methods for high school physics educators, particularly in the realm of making modern physics accessible for educators and learners, Dr. Alice Flarend is hereby named as the recipient of 2023 Paul W. Zitzewitz Award for Excellence in K-12 Physics Teaching."

Regarding her selection for this award Flarend said, "I am honored to be chosen to join the list of recipients, and I must thank the many people who have inspired and pushed me outside the traditional teaching norms to try new things."

Flarend's B.S. in Nuclear Engineering is from the University of Illinois – Urbana. She earned her M.S. in Nuclear Engineering at the University of Michigan – Ann Arbor, her Certification in Secondary Physics and Chemistry at the University of Pittsburgh – Johnstown, and her Ph.D. in Curriculum & Instruction at Pennsylvania State University – University Park. She is also National Board Certified and co-author with Bob Hilborn of the book Quantum Computing from Alice to Bob.

Flarend began her distinguished service as a PTRA workshop leader over 15 years ago after first attending Central PA Section PTRA workshops. Several years ago she became a part of the Central PA PTRA workshop team and has stepped into the lead role in planning and presenting the Central PA PTRA workshops, In addition to being a regular workshop leader, she has also been serving as the High School representative on the Executive Board of the Central PA Section of AAPT.

In her role as a PTRA workshop leader Flarend has dedicated herself to furthering the mission of providing excellent professional development programs for other teachers which involves sharpening her own pedagogical skills. In addition to the workshops in Central PA, she has presented a workshops for the Western PA Section of AAPT and as well as National AAPT meetings and meetings of other sections (including Texas, New York and New England).

Flarend has also taken on a leading role in the development of curricular materials and presentations for the Quantum for All program. This program aims to help teachers incorporate quantum topics into their traditional curriculum, thereby expanding the realm of high school science into cutting edge and exciting topics. She was created a semester long quantum physics course in her high school, enticing students at a variety of academic levels to learn about the science behind such topic as electron orbitals, quantum key distribution and quantum computers.

The Power of Words

We come to AAPT meetings to talk about physics. We share ideas and collaborate in order to find that perfect analogy to describe potential energy or how to setup a demo. Many conversations result in thought-provoking questions from peers about how or why we do certain things. These communications help us learn. We improve our understanding and, ultimately, our work.
I will argue language is an often overlooked but powerful pedagogical tool in the classroom. Of course, we all talk to our students, but do we talk with our students? Are we the only ones talking? Using language for learning means not only the language a teacher uses in explaining ideas, but also the opportunities the student has to communicate. Students have different experiences that influence their path to building an interconnected model of the world of physics. In building a more robust and nuanced model, they need to share their understandings, explain their unique connections and evaluate the ideas of others. Physics classroom should be filled with student voices and student ideas.

The Power of Words

Tuesday, July 18

11:30 a.m. – 12:30 p.m.

Ballroom A01

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.

Homer L. Dodge Citation for Distinguished Service to AAPT

Tuesday, July 18 • 11 a.m. – 11:30 a.m. • Ballroom A01

Catherine Herne

Catherine Herne

Catherine Herne will receive the association's Homer L. Dodge Citation for Distinguished Service to AAPT, during their 2023 Summer Meeting. Herne is honored:

"For tireless service to bringing attention to the importance of equitable learning spaces, and for exceptional contributions and consistent leadership that have helped develop foundational principles and structure to serve as a guide for realizing AAPT diversity,

Regarding her selection to receive this citation, Herne said, "I am honored to receive this award as a part of AAPT's movement towards a more diverse, inclusive, and equitable association and physics community. I continue to be amazed by the efforts of AAPT members and staff and their commitment to this ongoing work."

Herne is an Associate Professor in the department of Physics and Astronomy at the State University of New York at New Paltz, in New Paltz, New York. She earned her A.B. in Physics and Mathematics at Bryn Mawr College, Bryn Mawr, PA and her Ph.D. in Applied Physics at the University of Michigan, Ann arbor, MI.

Herne has been a key leader of AAPT's Diversity Equity and Inclusion (DEI) Task Force. The efforts of the Task Force will reshape the Association's understanding of how to best serve its diverse membership, and will support both teachers and students of physics in the 21st century. Her leadership was central, and her work enabled the Task Force to complete its initial goals.

Additionally, Herne serves in other roles in AAPT, such as being part of the chair chain in the Committee on Laboratories, she was one of the authors of the recent AAPT White Paper on the Increase Investment in Accessible Physics Labs: A Call to Action for the Physics Education Community. This major whitepaper was recently endorsed by the AAPT Board of Directors.

Herne has been appointed to represent AAPT on AIP's Diversity, Equity, Inclusion, Belonging, and Accessibility (DEIBA) strategic Framework Work Group. The purpose of the group is to offer all AIP Member Societies the opportunity to assist with the development of the DEIBA Strategic Plan. Member Societies will inform the process by providing input on the intended strategies for implementation and feedback on various compo**nents of the plan.**

Herne serves on the SEA Change Professional Association Assessment Team, as Regional Director, NY State region for the Advanced Laboratory Physics Association, and has given many contributed and invited talks at our meetings.

The Homer L. Dodge Citation for Distinguished Service to AAPT was established in 1953, was renamed in 2012 to recognize the foundational service and contributions of Homer Levi Dodge, AAPT's first president. The Homer L. Dodge Citation for Distinguished Service to AAPT recognizes AAPT members for their exceptional contributions to the association at the national, section, or local level.

The 2023 Fellows:

Lin Ding, Physics Education Researcher at the University of Ohio, Columbus, Ohio
Richard Gelderman, Western Kentucky University

Danielle Buggé

Wednesday, July 19

11–11:30 a.m.

Ballroom A01

2023 Homer L. Dodge Citation for Distinguished Service to AAPT:

Glenda Denicolo

PhysTEC Teacher of the Year: Danielle Buggé

The 2022 National Teacher of the Year is Danielle Buggé of West Windsor-Plainsboro High School South in Princeton Junction, NJ. Buggé was nominated by PhysTEC institution Rutgers University, from which she graduated.

Throughout her 13-year career, Buggé has created an environment where students develop confidence in science, communication, and collaboration. From her dedication to students and the teaching of physics, many successes followed.

PLENARY I: Challenges and Innovations for Inclusive Assessments for Blind Students in STEM

by Cary Supalo, Educational Testing Service (ETS)

In a recent collaboration, the Educational Testing Service and the Carnegie Foundation announced this new refocus on skills development in assessment – a priority that will redefine how STEM assessments are designed and conducted in the United States. This zeitgeist and its new innovative access technologies will make more inclusive STEM assessments possible. What then is inclusive assessment design? The answer varies depending upon the respondent to this deep question. This presentation will describe where we are today with assessments, how new innovative technologies are shifting the needle towards assessments for skill development and away from time-based approaches, and discuss some innovations on the horizon. Inclusive assessment design works in conjunction with inclusive curricula. As textbook publishers and science education technology firms become more inclusively minded, so too will the STEM subject fields. As STEM industry standards shift towards inclusion, so too must the education profession. Inclusion can and will be the future of STEM education.

Cary Supalo

Monday, July 17

11:30 a.m. – 12:30 p.m.

Ballroom A01

PLENARY II: *Anna Quider*

Dr. Anna Quider brings over 15 years of experience and award-winning leadership spanning higher education, the federal government, and the nonprofit sector to helping clients define and achieve their strategic goals. As a former professional astrophysicist, Anna unites a systems-thinking, analytical approach with enthusiasm and creativity to support clients in co-creating unique solutions to their challenges and driving measurable results. She adeptly guides clients through complex issues and ambiguity, with particular strengths across the science, technology, innovation, and higher education sectors; federal government processes and engagement; program and process optimization; and stakeholder engagement. Diversity, equity, and inclusion are Anna's foundational values and she utilizes a DEI lens for her engagements.

Anna Quider

Monday, July 17

4:30 – 5:30 p.m.

Ballroom A01

PLENARY III: TEAM-UP Together: Supporting African American Student Success through Systemic Change TEAM UP Together Update – *Arlene Knowles*

The 2020 TEAM-UP report, The Time Is Now: Systemic Changes to Increase African Americans with Bachelor's Degrees in Physics and Astronomy, states that unsupportive environments in many physics and astronomy departments and enormous financial challenges faced by African American students contributed to their underrepresentation in these fields. To address these issues systemically, TEAM-UP Together (TU-T), a new collective action initiative led by the American Institute of Physics, American Association of Physics Teachers, American Astronomical Society, American Physical Society and the Society of Physics Students, was started. TEAM-UP Together takes a multipronged, multilayered approach to support the scientific community in taking the next bold step to double the number of African American students earning physics and astronomy bachelor's degrees annually by 2030. This program provides direct support to Black students, while providing funding and resources to physics and astronomy departments committed to doing the work needed to address STEM equity at their institution and design programs that support the success of Black students. In this plenary, Ms. Knowles will discuss the work that TU-T is doing to engage the community in this program, the impact the program is having on students today, and the future plans for creating systemic change that will transform the education of students, especially, Black students.

Arlene Knowles

Tuesday, July 18

11:30 a.m. – 12:30 p.m.

Ballroom A01

PLENARY V: Diversity in Physics and Astronomy Update – *Rachel Ivie*

Beyond Representation: Data to Improve Equity in Physics and Astronomy

The American Institute of Physics (AIP) collects data on the representation of women and members of other underrepresented groups in physics and astronomy at all levels, from high school students to faculty members. Although indicative of some trends, these data do not tell the whole story. For physicists and astronomers who persist despite being underrepresented, data show that there are additional barriers to equitable participation. For example, women physicists who responded to a global survey reported that they have less access to career-advancing resources than men reported. In addition, AIP's TEAM UP report documents factors that contribute to the low numbers of Black undergraduate students in physics and astronomy. A recent AIP study of the effects of COVID on undergraduate physics and astronomy students showed more negative effects for those who are from marginalized groups than for those who are not marginalized. The effects of barriers such as these combine to create an accumulation of disadvantage that can set back individual scientists' careers and impede scientific progress. Data on inequity in physics and astronomy are essential so that we may design programs and practices that will allow full participation for all.

Rachel Ivie

Wednesday, July 19

11 a.m.–12 p.m.

Ballroom A01

K-12 RESOURCE ROOM SCHEDULE – Meeting Room 08

MONDAY

Time: Monday, July 17, 9 a.m.

Title: Topical Discussion: AP/IB Physics: Balancing Investigation with Test Prep

Join your K-12 colleagues teaching college level Physics to discuss challenges and successes in teaching test assessed physics courses.

Time: Monday, July 17, 10 a.m.

Title: Topical Discussion: Making Physics Accessible to all students

Come to discuss with colleagues strategies, successes and challenges of making Physics accessible for students with diverse backgrounds and needs including students within special education, students with lacking math skills, and more.

Time: Monday, July 17, 1 p.m

Title: California & Nevada teachers meet-up

Come meet with other teachers of all levels from California and Nevada. Members of the Southern California and Northern California & Nevada sections of AAPT are hosting an informal meet-up. It's a chance to chat and talk about the conference so far, and what you're excited about going to next.

Time: Monday, July 17, 2:30 p.m.

Title: Intern Talks

Come to hear from AAPT's K12 Professional Development Intern. Learn about her areas of interest, expertise and experience.

Time: Monday, July 17, 3:30 p.m.

Title: Physics for 9th Graders

Join a discussion on 9th grade Physics. Explore the differences and similarities between a 9th and 12th grade physics class as we make a traditionally senior level class developmentally appropriate and accessible to 9th grade students of all abilities.

TUESDAY

Time: Tuesday, July 18, 9 a.m.

Title: STEP UP in the High School Physics classroom

The STEP UP curriculum includes the Careers in Physics and Women in Physics lessons to introduce students to different job options in physics and lead them through a discussion of who historically has done physics. Adaptations and implementation suggestions will be discussed for these NGSS aligned lessons.

Time: Tuesday, July 18, 10 a.m.

Title: Topical Discussion: Integrating computer science

Join your K-12 colleagues to discuss challenges, successes, and specific strategies in meaningfully and effectively integrating computer science into a high school physics course.

Time: Tuesday, July 18, 10:30 a.m.

Title: Topical Discussion: Building relationships in the High School Physics Classroom

Join your K-12 colleagues to discuss building a classroom culture. Share strategies you use in your physics class that promotes collaboration and respect in student-student and student-teacher relationships.

Time: Tuesday, July 18, 2:30 p.m.

Title: A Dive into the Standards

Have you ever taken the time to examine the standards that you are teaching? What comes before and what comes after your class? What parts of your curriculum are actually standards aligned and what is extra? Use this time to dive deep into California (NGSS) standards.

Time: Tuesday, July 18, 3:30 p.m.

Title: Physics in Elementary

Join a discussion on the state of science, specifically physics, in elementary. Learn about elementary teachers' greatest challenges and needs for successful and effective science instruction.

EXHIBITORS AT SUMMER MEETING

Exhibit Hall: Convention Center Exhibit Hall A

Hours: Sunday: 6:30–8:30 p.m. Opening Reception
Monday: 10 a.m.–5 p.m.
Tuesday: 10 a.m.–4 p.m.

Arbor Scientific

Bedford, Freeman, & Worth High School Publishers

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Society of Physics Students

McGraw Hill

PASCO Scientific

Quantum Experience Ltd.

THE EXPERT TA

Thor Labs

Vernier Science Education

APSIT Group Member Insurance Program

Wednesday Speaker, Phil Kass

Wednesday 8–9 a.m. Ballroom A01

How the University of California has adapted to a race-conscious ban on faculty hiring since 1996, with implications for student admission

Phil Kass, vice provost of academic affairs at UC-Davis

Phil Kass
UC Davis

Commercial Workshops at Summer Meeting

An Online Homework Solution and Custom Publishing for Intro Physics (Expert TA: Monday, 10–11 a.m., Meeting Room 04)

Expert TA's platform has been a trusted online homework resource for Introductory Physics for over a decade with advanced question-types, immediate feedback for incorrect answers, and academic integrity features to address cheating. We also function as a digital publisher, helping schools deliver things like lab manuals with automatically-graded pre-lab quizzes, lecture notes, and course packs with accompanying Expert TA assessments. We are now progressively releasing a powerful but easy to use eBook editor, and corresponding eReader that will provide instructors with the ability to fully edit any of the OpenStax textbooks. Instructors will be able to rearrange, rewrite, change/add images, add new sections/chapters, etc. Instructors can also use our platform to custom publish their own textbook, lecture notes, or other class materials. Expert TA is currently using this same platform to create revised editions of OpenStax College Physics, University Physics Vols 1-3, and OpenStax Astronomy; and we are open to and seeking input from the community about where to prioritize our editorial efforts. If you currently use OpenStax, or are considering adopting, but feel that you need changes, you now have options. With our new initiative, it will be possible for instructors to either edit the OpenStax books directly or communicate with us and let our team do the work. If you are interested, please join us to learn more.

Introduction to Physics: Interactive Learning Resources That Help Students Build Skills to be Successful (McGraw Hill: Tuesday, 12:30–1:30 p.m., Meeting Room 02)

Discuss and provide feedback on new digital tools from McGraw Hill designed to bridge the gap between lecture and lab while building student computational analysis skills. These tools help Algebra- and Calculus-based Physics students learn data acquisition and analysis, and addresses numerical computation of derivatives while providing a simple way to include more computation in the introductory curriculum. See a demonstration of interactive tools that are being developed to help university and community college students learn physics by actively engaging with the material. Participants will be able to provide feedback to guide development of these resources. Your input plays a critical role to ensure we develop tools students need to be successful.

Beyond Logger Pro®: Revolutionize Learning with Vernier Technology and Tools (Vernier Science Education: Monday, 1–2 p.m., Meeting Room 04)

Dave Vernier and Tom Smith

Bring hands-on physics learning to your classroom with the best in Vernier technology! Whether you're a longtime user of Logger Pro or new to Vernier, this is your chance to get acquainted with some of our newest award-winning software. Join us to explore Vernier Graphical Analysis® Pro and Vernier Video Analysis® apps, as well as VPython—all accessible from your personal device! Walk away with a free trial for both Graphical Analysis Pro and Vernier Video Analysis.

Connecting Physics and Physiology through Vernier Video Analysis® (Vernier Science Education: Monday, 2:30–3:30 p.m., Meeting Room 04)

Tom Smith and Fran Poodry

Your students can explore running, jumping, and weight lifting like never before with our Vernier Video Analysis app! Here's your opportunity to collaborate with your physiology colleagues to connect physics to human motion. Walk away with a free trial of Vernier Video Analysis, as well as tips on setting up good video shots, preparing videos for analysis, and collecting appropriate data.

Engaging Mechanics Demos Using the Smart Cart Demonstration Kit (PASCO Scientific: Tuesday, 10–11 a.m., Meeting Room 04)

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.

Teaching Rotation with the Meter Stick Torque Set (PASCO Scientific: Tuesday, 1–2 p.m., Meeting Room 04)

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.

AAPT Exhibitors

Exhibit Hall A: Sunday, 6:30–8:30 p.m.
Monday, 10 a.m.–5 p.m., Tuesday, 10 a.m.–4 p.m.

AAPT

One Physics Ellipse
College Park, MD 20740
301-209-3300, www.aapt.org

AAPT® is a strong professional physics science society dedicated to the pursuit of excellence in physical science education. Want to know more about AAPT's mission, history, goals, and organizational structure? Stop by our booth to learn more and get involved!

AAPT Publications

https://www.aapt.org/publications/

AAPT® publishes two peer-reviewed journals and many other publications in both print and online. The American Journal of Physics® is geared to an advanced audience, primarily at the college level. The Physics Teacher® focuses on teaching introductory physics at all levels. AAPT eNNOUNCER, is an online-only publication that summarizes recent news from the association, its members, its partners, and from the physical sciences world in general. .

AAPT Nominating Committee

www.aapt.org

TThe AAPT Nominating Committee strongly encourages interested AAPT members to submit a nomination for any Board of Directors or Area Committee position.

aiPlato

https://aiplato.ai/

Many studies confirm that compared to one-size-fits-all education, one-on-one teaching boosts student performance by 2 standard deviations & makes students more engaged in learning. We are on a mission to bring the benefits of one-on-one education to every K-12 student by building the AI-embodiment of one-on-one teaching. A decade of extensive research by our esteemed education experts is distilled into this AI. The time has come to provide every student with an interactive learning experience equivalent to one-on-one teaching – personalized to their cognitive processing in real-time - and for online education to help students overcome obstacles in acing every problem - watching every error, diagnosing the root cause, & reinforcing knowledge-gaps, like a one-on-one teacher. We must turn education from a chore that students dread into an enjoyable game-like experience. And yes, human tutoring must be accessible to every student, assisted by AI.

APSIT Group Member Insurance Program

apsitinsurance.com

The American Physical Society Insurance Trust (APSIT) has been providing top-tier insurance for science professionals like you for over 50 years. We offer insurance products to all member societies under the American Institute of Physics (AIP) umbrella, and our mission is to provide you with a convenient, trustworthy source for your personal insurance needs. Visit us at booth 211 to see how we can help protect you and your family.

Arbor Scientific

www.arborsci.com

Arbor Scientific is a leading provider of Physics and Physical Science teaching equipment. We work with teachers at all levels to provide unique demonstration and laboratory tools – and then provide lesson plans, supportive teaching guides, and science teaching supplies to make each learning experience fun and effective.

Bedford, Freeman, & Worth High School Publishers

https://www.bfwpub.com/high-school/us

BFW Publishing Group consists of three distinct publishing houses—Bedford/St. Martin's, W.H. Freeman, and Worth Publishers—and unlike some publishers, BFW is a privately owned company. We are proud of our extensive publishing history and our focus on our customers. Our authors consist of renowned leaders in their disciplines, recognized leaders in the AP® communities, and leading authorities on the AP® courses. They are Nobel Prize winners, award-winning novelists, and cutting-edge researchers. They are college professors and AP® teachers. They are in the classroom every day: just like you.!

Digitalis Education Solutions

www.digitaliseducation.com

Digitalis started the affordable digital planetarium revolution back in 2003. We are now the leading global manufacturer of these immersive simulators. A digital planetarium allows you to travel anywhere through time and space, making spatial concepts much easier to teach. Despite the name, you are not limited to astronomy topics. Using a fixed or portable dome, you can create mind-expanding shared immersive experiences for entire groups—no VR goggles required!

Expert TA

www.theexpertta.com

We are an independent commercial online homework and tutorial system, providing software as a service to students and educators. Our software provides human-like grading capabilities, unique problems, and customized hints and tips to engage students, drive discussions, and improve student learning and teaching results.

KUDU

www.kudu.com

Kudu creates high-quality learning materials integrated into a versatile learning platform and makes them available to the students at a fraction of the cost of available alternatives. We offer digital textbooks supplied with an auto graded online homework, high-quality videos and a 'clicker.' The courses are well aligned with modern teaching practices, making it easy for instructors to engage students in active learning. The digital 'textbooks' are fully editable, and professors are free to customize them for their courses or Professors are welcome to use the robust kudu content. We also encourage professors to contribute content, helping to improve the catalog of courses offered through Kudu. Kudu is committed to supporting the academic ecosystem by offering student fellowships, sponsoring research conferences and other academic activities. If you want to join us in development of modern, high-quality, low-cost learning materials, we look forward to hearing from you.

Las Cumbres Observatory - USA Sky Partners

https://lco.global/education/usa-sky-partners/

Our mission is to provide an authentic astronomy research experience for US undergraduates, where they complete the program feeling that the ability to do science is part of their identity. No prior interest in or experience doing science is required. The USA Sky Partners is a new program where LCO provides access to our global robotic telescope network and partners

with US colleges and universities that reach students from groups that are underrepresented in astronomy. The student research program is an 8-week workshop that can be done separately or in conjunction with an introductory astronomy course. The observing experience utilizes the ten 0.4m telescopes in the LCO network. All that is required to observe with LCO telescopes is a computer with access to the internet and an allocation of telescope time.

McGraw Hill

https://www.mheducation.com/highered/home-guest.html

Our vision is to guide you along the path to unlock your potential, no matter where your starting point may be. We'll help you access all the value that education can offer, through high-quality, trusted content developed with world-class authors – and flexible tools to meet the needs of different teaching and learning styles. Our digital platforms provide data-driven insights, adapting to help meet learners where they are – and advancing with them as they progress toward their goals.

PASCO Scientific

www.pasco.com

Students need modern tools and technology to succeed in STEM. At PASCO, we have been creating and manufacturing award-winning, hands-on science education tools and datalogging solutions since 1964. With our unique blend of dedication and experience, we think no one combines innovative, easy-to-use products with world-class support like we do.

Quantum Experience Ltd.

www.quantumlevitation.com

Motivate and inspire students to explore the world of physics by educating them about fascinating topics such as Superconductors, Quantum Levitation, Magnetic Levitation, and beyond. Quantum Experience creates educational resources and instructional materials that allow students to engage in a research-oriented learning process, fostering the development of crucial scientific skills..

Society of Physics Students

www.spsnational.org

The Society of Physics Students (SPS) is a professional association explicitly designed for students and their advisers. Membership, through collegiate chapters, is open to anyone interested in physics. The only requirement for membership is that you be interested in physics. Besides physics majors, our members include majors in astronomy, chemistry, computer science, engineering, geology, mathematics, medicine, and other fields. SPS is open to everyone. Within SPS is housed Sigma Pi Sigma, the national physics honor society, which elects members on the basis of outstanding academic achievement. This unique two-in-one society operates within the American Institute of Physics, an umbrella organization for ten other professional science societies.

Thor Labs

www.thorlabs.com

Thorlabs has proudly served the photonics industry for 30 years with an extensive portfolio of tools and equipment. Our expanding Thorlabs' Discovery line of educational products aims to promote physics, optics, and photonics education and demonstration. Covering topics from classic physics experiments to emerging fields of research, the kits can be used in college lab courses or as demonstrations during a lecture. Each physics lab experiment includes components for building the setup and a manual that contains both detailed setup instructions and extensive teaching materials, with technical support available from our educational team both before and after purchase. .

Vernier Science Education

https://www.vernier.com/

For more than 40 years, we have empowered educators like you with world-class data-collection technology and innovative experiments. Your passion and dedication, along with the implementation of high-quality sensors, experiments, and resources in your classroom or laboratory, enable your students to explore science in new ways. Our mission is to provide you with the tools you need to encourage scientific curiosity in all students. See what partnering with us can do.

enhancing the understanding and appreciation of physics through teaching

AAPT makes me a better teacher, but it's more complicated than that. AAPT provides a forum not only for improvement but for questioning our practice. Attending an AAPT meeting inspired two other teachers and myself to start EnergyTeachers.org. I go back to AAPT every year for new inspiration.

— Shawn Reeves, EnergyTeachers.org

National Meetings

- Held bi-annually, winter and summer
- Talks by internationally known physicists and educators
- Research and teaching presentations
- Professional development sessions
- Workshops for Continuing Education Units (CEU)
- Apparatus Competition

Workshops & Conferences

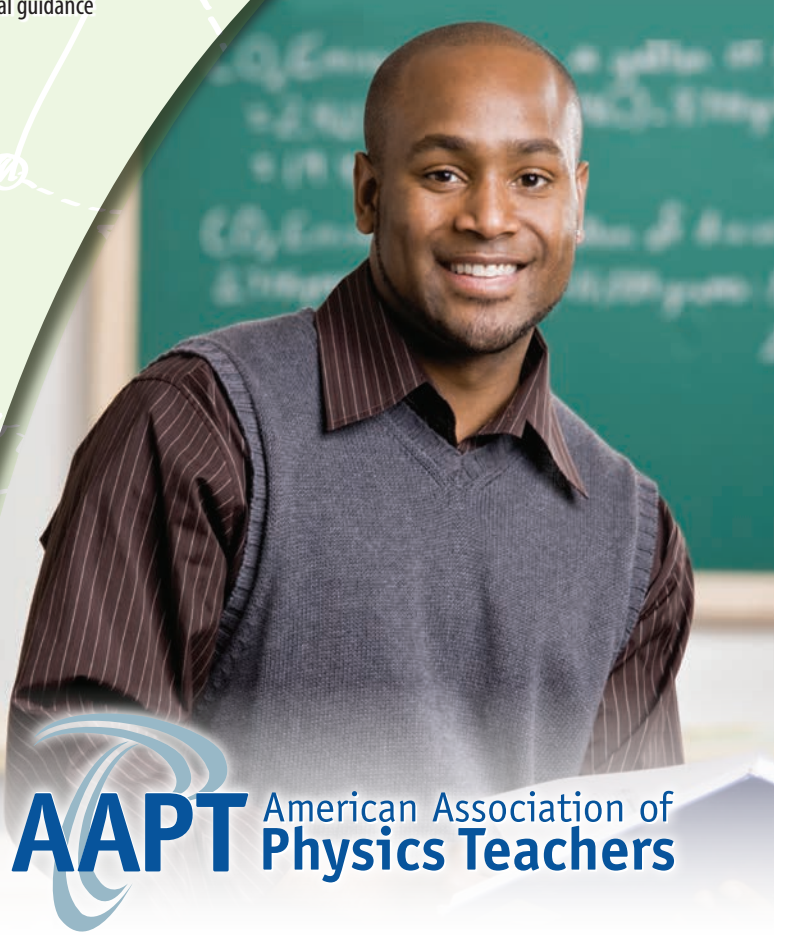
- Physics Department Chairs Conference
- Workshops for New and Experienced Physics & Astronomy Faculty: twice yearly training for physics and astronomy faculty

Online Resources

- AAPT eNNOUNCER
- eMentoring: connects high school physics educators who desire additional guidance
- ComPADRE: digital physics and astronomy collections
- Career Center: online resume postings, ads, inquiries and interviews
- Physics Review Special Topics
- Physical Sciences Resource Center: teaching materials and ideas
- Topical listservs

Awards & Honors

- Oersted Medal
- Millikan Medal
- Klopsteg Memorial Lecture Award
- Richtmyer Memorial Lecture Award
- Melba Newell Phillips Medal
- Homer L. Dodge Citation for Distinguished Service to AAPT
- Paul W. Zitzewitz Award for Excellence in K-12 Physics Teaching
- David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching
- John David Jackson Award for Excellence in Graduate Physics Education



aapt.org

AAPT American Association of Physics Teachers

Saturday, July 15, 2023

Astronomy Data, Image Analysis, and Research Using Web-based JS9

Time: 8:00 AM to Noon Saturday **Ballroom A05** **Organizer: Pamela Perry**

How can we provide an authentic research experience to students who want to find out what science is REALLY about? We couple JS9, a fun to use, web-based image display environment, with archival satellite data to allow students to perform astronomical analysis remotely using their browser. Energy spectra, light curves, periodic phenomena, and much more can be explored, using data from thousands of deep sky objects, spanning the gamut of observed energies, from infra-red emission to gamma rays. Since this system is platform independent, it is especially useful in the classroom, as well as in distance learning environments. Classroom ready activities and js9 user guides are available. Students explore false color images, the chemistry and physics of supernova, and merging galaxies and more and develop their own research projects. Participants will be refunded for the cost of this workshop.

Exploring Physics through the Lens of Systems

Time: 8:00 AM to Noon Saturday **Ballroom A10** **Organizers: 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 real objects are more complicated, and every object can be thought of as part of a large system. 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 (one of the NGSS crosscutting concepts) by seeing how small changes or additions to units commonly found in introductory (including AP) physics courses (forces, momentum, energy) can help students think in terms of systems. We will explore this idea through labs, problems, and discussions. Thinking in terms of systems will even allow us to naturally develop the idea of center of mass. Although we hope that this workshop will be interesting to a wide audience, our target audience is high school teachers.

Highlights from 20+ years of the PTSOS Workshop Program for New Physics Teachers

Time: 8:00 AM to Noon Saturday **Ballroom A06** **Organizer: Dan Burns**

The PTSOS program has been an integral part of the NCNAAPT section for over 20 years. Started as a workshop at the section meetings, it has grown to a workshop program held on three Saturdays during the school year. This workshop will feature many of the favorite demos, activities, and techniques from the PTSOS workshops. Past, present, and future? PTSOS presenters will share their expertise and the fun of teaching physics. We also welcome the contributions from the participants as we discuss how to teach physics. Participants will leave with some of the equipment used in the workshop, free of charge. The workshop is targeted at high school teachers. However, the feedback from college and middle school participants over the years indicates it will be rewarding for all that can attend. Participants who complete this workshop will be reimbursed for their registration fee thanks to the Scott Chan Memorial Fund.

PIRA Lecture Demonstrations I & II Condensed

Time: 8:00 AM to Noon Saturday **Ballroom A09** **Organizer: Dale Stille and Sam Sampere**

During this ½ day workshop, we will introduce you to the Physics Instructional Resource Association (PIRA) and the PIRA 200. Almost every demonstration one can think of has a catalog number within the Demonstration Classification System (DCS); we will introduce you to this system and the comprehensive bibliography that details journal articles and demonstration manuals for construction and use in the classroom. The PIRA 200 are the specific 200 most important and necessary demonstrations needed to teach an introductory physics course. We will also show a subset of approximately 50 demonstrations explaining use, construction, acquisition of materials, and answer any questions in this highly interactive and dynamic environment. Ideas for organizing and building your demonstration collection will be presented. We especially invite high school physics teachers and faculty members teaching introductory physics to attend. NOTE that this is a paperless workshop. All information and materials will be distributed on a USB thumb drive (if requested) or other method. A computer, tablet, or other device capable of viewing and/or recording the workshop will be needed.

Supporting Students' Understanding of Work and Energy through Careful Use of Language

Time: 8:00 AM to Noon Saturday **Ballroom A08** **Organizers: Gay Stewart, Tiffany Taylor**

Energy and systems are fundamental, cross-cutting science concepts, and physics is the place to help students develop a deeper conceptual understanding. However, students hear what we say, not what we mean! Trying to simplify our discussions of work and energy (particularly potential energy) can generate increased confusion. We will look at a few examples of how common wording can generate incorrect models in energy and in related concepts some problems where incorrect models have surfaced how a change in wording can help our students develop a single coherent conceptual model for energy problems that significantly impacts their ability to use more robust problem-solving approaches and to describe and model physical situations.

3D Printed Interferometers

Time: 1:00 PM to 5:00 PM Saturday **Ballroom A07** **Organizers: David Sederberg, Chen-Lung Hung**

In this workshop we will present the culmination of a multi-semester service learning project during which we designed and field-tested table top interferometers for classroom instruction. Our interferometers utilize a steel plate, to which the base for each of the optical components are magnetically held in place, allowing students to independently assemble the apparatus and thus learn about the correct placement and function of each component in the optical path. The unique aspect of our design is that the base for the optical components can be 3D printed, allowing anyone with access to a suitable printer to replicate the design. The lenses, beam splitter and mirrors are all commercially available. The interferometer design provides an excellent model for the operation of LIGO and other interferometer applications, and the theory behind the research method. We will demonstrate the use of an inexpensive hand-held oscilloscope, with which your students will be able to validate the theory and sensitivity relative to this methodology. All relevant 3D files and a complete list of other materials and sources will be provided, as well as troubleshooting tips useful for making and using these devices in your own classrooms.

Fun, Engaging, Effective, Research-Validated Lab Activities and Demos for Introductory University, College and High School Physics (including Virtual Learning Options)

Time: 1:00 PM to 5:00 PM Saturday Sheraton - Tofanelli Organizer: David Sokoloff

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. Please bring your laptop.

MARVLS – Manipulable Augmented Reality Visualizations to Learn Spatially

Time: 1:00 PM to 5:00 PM Saturday Sheraton - Compagno Organizer: Michele McColgan

A goal of this workshop is to introduce you to MARVLS. Our augmented reality App contains over 60 augmented reality models of physics concepts. Attendees are invited to load our App available on the App Store or the Google Play Store to their iPhone or Android phone. Using a cube as the target, attendees will view the augmented reality models of 3D and abstract concepts in electrostatics, magnetism, circuits, electromagnetism, and optics. In this workshop we will provide you with curricular materials to use the MARVLS for classroom demonstrations and as classroom or homework activities. You'll receive an AR cube and cube templates to share with your students. Finally, we'll step through the process of creating an augmented reality model in Unity.

Optics from Aristotle to Newton

Time: 1:00 PM to 5:00 PM Saturday Ballroom A08 Organizer: Scott Bonham

Studying how European and Islamic scholars developed modern geometric optics over a period of nearly two thousand years is a useful way to help students develop a better understanding of the history and nature of science. In this workshop I will share simple hands-on activities, selected historical texts, whole classroom presentations, and supporting curricular materials that I use with my conceptual physics students to help them learn basic physics principles, explore the history of science, and develop scientific argumentation skills. We will in particular highlight the intellectual foundations of science laid down by Aristotle, the empirical development of optical theory by the medieval Arab scientist Ibn al-Haytham, and the clash between Isaac Newton and Robert Hooke at the dawn of modern physics emerged that prefigured the future development of the wave-particle theory of light. These activities and readings could be used with students at a variety of levels.

Strengthening Reasoning in AP Physics (and Beyond) with Multiple Representations

Time: 1:00 PM to 5:00 PM Saturday Ballroom A06 Organizers: Kathleen Harper, Jeff Funkhouser, Rebecca Howell, Amy Johnson, John Pinizzotto, Jesse Miner

Over the past several years, new resources have been developed to support instructors of AP physics courses, both in terms of incorporating new tools into their teaching and in terms of preparing their students for the styles of questions asked on AP exams. This workshop will first give an overview of the general structure of the AP courses and exams. One of the emphases of the course and exam is on reasoning with multiple representations (words, diagrams, equations, graphs, etc.). Participants will work through and discuss a variety of classroom exercises utilizing a variety of representations. While these curricular tools will be presented in the context of AP courses, they are impactful throughout physics teaching.

Tools for Using Smartphones in the Astronomy Classroom

Time: 1:00 PM to 5:00 PM Saturday Ballroom A10 Organizer: Kevin Lee

This workshop will motivate and demonstrate efforts to utilize student smartphones in the college introductory astronomy classroom. These devices are extremely prevalent in today's society and our students have a very strong devotion to them. Smartphones offer a unique opportunity to forge connections between students and science content. Participants will be exposed to an online HTML5 ranking and sorting task editor and examples created in it. The necessary steps to create tasks will be illustrated and then participants will be asked to create their own tasks online and save them locally. We will then describe the desirable characteristics of HTML5 simulations targeted at smartphones and examples illustrating these characteristics. Participants will experience a smartphone simulation as a student and another as an instructor, formulating a plan for guiding their students in its usage. Special emphasis will be placed on simulations useful for the upcoming widely observable solar eclipses in 2023 and 2024 as well as recently developed HR diagram simulations. We will conclude with a discussion of current thinking regarding "best practices" for smartphone usage in the classroom, covering what is known and brainstorming on what is unknown. It is expected that participants will have a smartphone in hand that they will be putting to work accessing astronomy content through QR codes. It would be optimal if they also had a laptop for ranking and sorting task creation. Participants will be reimbursed $35 after completion of the workshop.

Sunday, July 16, 2023

Learn Physics While Practicing Science: Introduction to ISLE

Time: 8:00 AM to 5:00 PM Sunday Ballroom A07 Organizers: David Brookes, Yuehai Yang, Yuhfen Lin, 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. We will focus on the connections of our materials with the NGSS and revised AP curriculum, specifically on the interplay of science practices and crosscutting concepts. 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.

Biomechanics Introductory Lab Activities

Time: 8:00 AM to Noon Sunday Ballroom A10 Organizer: Nancy Beverly

Get hand-on experience with video analysis, force plates and goniometers for introductory biomechanics activities that students can do on their own bodies. Students can learn all basic mechanics within the context of biomechanics or just explore some or one. Whole body dynamics and limb motion and muscle forces can be examined separately or together. Learn tips on how to best acquire and analyze human movement data, which can be messier, with non-constant acceleration, and more complex than typical lab data, but more meaningful for students. Setting up appropriate comparisons, students can frame their own questions that their human movement analysis can address. Recognition of limitations on data and models used to analyze the data have real-life significance. Participants can try out provided scenarios or design their own. Best to come with your own laptop, installed with either Pasco Capstone or Vernier Graphical Analysis Pro software (both available as free trials)

Coding Integration and Data Science Integration in High School Physics and Physical Science

Time: 8:00 AM to Noon Sunday Ballroom A09 Organizers: Chris Orban, Jimmy Newland

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 against a solid colored background. Students can analyze the tracking data in Excel or Google sheets to extract the velocity and acceleration as a hands-on introduction to data science. These activities are part of a much wider curriculum that is highlighted on the STEMcoding YouTube channel (http://youtube.com/c/STEMcoding). AIP Grant Funds will reduce the price of this workshop. Participants will be reimbursed $50 post-workshop.

Creating Curricular Materials to Accompany Physics Simulations

Time: 8:00 AM to Noon Sunday Ballroom A11 Organizers: Manher Jariwala, Emily Allen

The goal of this workshop is, as a group, to create curricular materials (e.g., recitation activities, class worksheets, or simulation-based labs) that are based on this set of 200+ physics simulations that are aimed at introductory physics at the college level, as well as high school physics. https://physics.bu.edu/~duffy/sims.html There are already some existing curricular materials, created by our Boston University group as well as by others, so we'll look at what already exists, and then take some time to build, individually or in small groups, more materials that we can share and make use of in our own classes.

Developing the Next Generation of Physics Assessments

Time: 8:00 AM to Noon Sunday Ballroom A03 Organizer: James Laverty

Want to write assessments that will give you more evidence about what your students are actually able to do with their physics knowledge? If so, then this is the workshop for you. Participants will learn how to use the Three-Dimensional Learning Assessment Protocol (3D-LAP; a research-based protocol) to develop in-class, homework, and exam problems that engage students in both the process and content of physics. This instrument was developed to help assessment authors at all levels generate questions that include scientific practices, crosscutting concepts, and disciplinary core ideas, the three dimensions used to develop the Next Generation Science Standards. Join us to learn how to create the next generation of physics assessments.

Interactive Video-Enhanced Tutorials for Promoting Problem Solving

Time: 8:00 AM to Noon Sunday Ballroom A02 Organizers: Kathleen Koenig, Alexandru Maries and Robert Teese

This workshop is for those interested in using or developing their own web-based problem-solving tutorials. Participants will learn about our 30 freely available Interactive Video-Enhanced Tutorials (IVETs), where each focuses on an important problem-solving approach (e.g., energy conservation), covering most chapters taught within a two-semester introductory physics course. IVETs include videos of a narrator (instructor) interspersed with multiple-choice questions, with feedback provided for correct and incorrect answers. The questions and feedback are designed to carefully step students through an expert-like problem-solving process, while emphasizing the reasoning behind each step, providing students with personalized learning. Workshop participants will work through an IVET, learn best practices for integrating IVETs into their courses, and receive an overview of the research findings that demonstrate their effectiveness. Participants will also learn how to create their own IVETs, including how to choose appropriate problems, write scripts with suitable multiple-choice questions and supportive feedback, and use our

Vignette Studio II software to assemble the IVETs. All of our IVETs and the VS II software are freely available at compadre.org/IVET. Participants are asked to bring a laptop to the workshop. Supported by NSF DUE-1821391 and DUE-1821396.

Maximizing Learning and Engagement with Demos

Time: 8:00 AM to Noon Sunday Ballroom A08 Organizer: Joe Kozminski

Attendees will learn about the Demonstration Framework and how to apply it to their demonstration development process. Attendees will start the session deciding with their own topic or concept they want to develop into a demonstration, and over the course of the workshop will go through the five (5) steps of the Demonstration Framework and finish with a fleshed-out draft for their demonstration.

AP Physics Course Revisions for Fall 2024

Time: 1:00 PM to 5:00 PM Sunday Ballroom A02 Organizers: Amy Johnson, John Pinizzotto, Jesse Miner

This workshop will introduce the revised AP Physics curricula to teachers. The goal of this workshop is to familiarize teachers with the new curricula and science practices. Session will begin with a brief introduction, providing context for the new curriculum and its goals. This will be followed by a deep dive into the key features and major differences between the new curriculum and its predecessor, with a focus on science practices. of the content changes for all four AP Physics courses, followed by a review of the new science practices. Attendees will be encouraged to participate in group discussions and activities. A significant amount of time will be devoted to developing skills in adapting and implementing the new curriculum within participants' classrooms. The session will conclude with an opportunity to review sample questions tied to each science practice in a case study. The revised AP Physics exams will be reviewed and strategies to prepare students will be discussed and modeled.

Intermediate and Advanced Labs

Time: 1:00 PM to 5:00 PM Sunday Ballroom A03 Organizer: Jeremiah Williams

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.

Introductory Labs to Promote Scientific Reasoning

Time: 1:00 PM to 5:00 PM Ballroom A04 Organizers: Kathleen Koening, Krista Wood, 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.

Let's Talk about Equity: The Underrepresentation Curriculum

Time: 1:00 PM to 3:00 PM Ballroom A05 Organizers: Abigail Daane, Elissa Levy

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 own classrooms, and collaborate with other instructors to create viable actions beyond the workshop.

LHC Physics in the Classroom

Time: 1:00 PM to 5:00 PM Sunday Ballroom A06 Organizer: 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 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.

Novel Observations in Mixed Reality (Virtual Reality in the Physics Lab)

Time: 1:00 PM to 5:00 PM Sunday Ballroom A08 Organizers: Jared Canright, Suzanne White Brahmia

Participants in this session will learn about incorporating virtual reality (VR) technology into the physics laboratory. This application of VR is based on the Investigative Science Learning Environment (ISLE), and focuses specifically on creating opportunities for students to test and generate new hypotheses associated with particle interactions. Participants will engage in activities the way students do, starting with a testing experiment of Coulomb's Law and moving into hypothesis-generating experiments with exotic matter that obeys known laws of physics, plus a few more. These activities facilitate students' engagement in the process of mathematical modeling of additional laws the particles obey in the VR space. Participants will learn to leverage VR technology to provide opportunities for students to be immersed in a complete cycle of quantitative hypothesis generation, testing, and revision. VR is used in this context for its immersive qualities and its appeal to students' familiarity with game play, specifically targeting the learning outcomes identified by the AAPT Lab Guidelines and the Science and Engineering Practices of the Next Generation Science Standards. It is important to bring a laptop to the workshop.

PICUP: Integrating Computation into Introductory Physics at TYCs

Time: 1:00 PM to 5:00 PM Sunday Ballroom A09 Organizers: Marie Lopez del Puerto, Larry Engelhardt

In this workshop, we will show you some ways in which computation can be integrated into your introductory courses. The PICUP partnership has developed a variety of computational activities for introductory physics, and we will show you how you can take these PICUP materials and adapt them to fit your needs. PLEASE BRING A LAPTOP COMPUTER. In this workshop, we will focus on computational activities using spreadsheets and web-based "Trinkets" so you do not need to have any specialized software installed. This workshop is supported by OPTYCs, The Organization for Physics at Two-Year Colleges (NSF-DUE-2212807).

Professional Development for Emerging Education Researchers (PEER)

Time: 1:00 PM to 5:00 PM Sunday Ballroom A11 Organizers: Scott Franklin, Mary Bridget Kustusch

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.

POSTER SESSION I:
Location: Exhibit Hall A **Sponsor:** AAPT
Time: 7–8 p.m. **Date:** Sunday, July 16

Astro (Astronomy and Astrophysics) Posters

A103 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Look UP, Below! An Educator's Guide to the April 8, 2024 Total Eclipse of the Sun

Presenting Author: Deborah Skapik, Friends' Central School

In the weeks leading up to the Great American Eclipse of April 8, 2024, teachers will need a reliable resource they can access quickly to provide their students with a firm foundation in eclipse literacy. I have written a book that offers K-12 teachers background material on eclipses not only as natural world phenomena but as historical and cultural events. It includes ready-to-go activity pages that teachers can duplicate and enjoy with their classes. Additionally, it gives step-by-step guidelines for each teacher to determine eclipse timing personalized to their geographic location. This poster will describe my plans to drive alongside the eclipse path from Illinois to Burlington in late July to distribute this book to teachers in Title 1 eligible schools. Copies will be available.

A105 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Mission to Mars: A Collaborative Approach to a Multidisciplinary Problem

Presenting Author: Matthew Pappas, Suffolk County Community College

Since 2012, a collaborative group project has been implemented into the curriculum of an introductory astrobiology course at Suffolk County Community College. What began as a hypothetical search for life on Mars has evolved into students designing a plan for prolonged colonization of the red planet from the ground up. Students identify the challenges of interplanetary space travel, as well as living on Mars for an extended period of time, then research technologically feasible solutions to those problems. Through this exercise students learn the interconnectedness of STEM fields, how proposed solutions to one specific problem hold consequences for other facets of the mission, and the potential implications such an endeavor can have on society and culture.

A107 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Astronomy Modeling with Exoplanets—Astrophysics for High School Students

Presenting Author: Colleen Megowan-Romanowicz, American Modeling Teachers Association

Additional Author | Daniel Peluso, UNiversity of Southern Queensland

This poster presents data from a distance learning Astronomy Modeling Workshop for teachers that was first offered in 2022, and case study data from students of one of the teacher participants in the 2022 workshop. We describe changes in content knowledge and confidence for both teachers and students as they learn the underlying physics models of spacetime, motion, forces, and light. Students in this data-intensive astrophysics course develop their image analysis skills, order images stacks from robotic telescopes and use their photometry data from these images to create light curves of exoplanet transits. Both teachers and students view this course as an equivalently rigorous learning experience to high school physics.

A109 (7:00 to 8:00 PMv) | Poster Presentation Traditional | Astro-OER: Activities, Interactive Lecture Slides, and Projects Aligned with OpenStax Astronomy

Presenting Author: Andrea Goering, University of Oregon and Lane Community College

Additional Author | Richard Wagner, Lane Community College

Adopting Open Educational Resources (OER) can seem like a leap of faith, especially since OER textbooks often offer limited ancillary materials. However, low-cost materials can bring down barriers for financially stressed students. Therefore, we have authored ancillaries aligned with the free OpenStax Astronomy textbook to enable future textbook adopters. The LCC Astronomy OER collection includes interactive lecture slides, activities that can be used in-class or as homework, and project prompts to connect learning to students' lives. The materials are designed for an interactive lecture or lecture-lab environment centered around peer learning. This poster shares our design goals and the resource collection. We are also happy to talk about the process of authoring OER and what we've learned in the process. Whether you're interested in adopting OER or are a physics or astronomy instructor interested in authoring, please stop by!
Find the collection: https://tinyurl.com/lcc-astr-oer

Beyond Introductory Physics Posters

(7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Integrating Portable X-ray Fluorescence (pXRF) into Undergraduate Courses, Including Teacher Preparation Courses!

Presenting Author: Elaine Christman, West Virginia University

Additional Author | Louis M. McDonald, West Virginia University

Additional Author | Jeffery Carver, West Virginia University

Additional Author | Vanessa Licwov-Channell, West Virginia University

Additional Author | Gay B. Stewart, West Virginia University

Additional Author | Lynnette SOGB Michaluk, West Virginia University

In an effort to engage more students in science we are seeking to develop regionally relevant classroom activities and community-based participatory research projects. With a grant from the NSF we were able to purchase a pXRF that we use in both undergraduate STEM majors' and future HS teachers' curricula. The pXRF provides the ability to conduct in-situ measurements. These field analyses allow for rapid screening, for example, of heavy metal contamination within public parks and brownfield sites. Participating students receive safety training prior to use of equipment. They gain experience with using a modern analytical technique, hypothesis testing, field and analytical methods, data analysis, interpretation, and oral and written dissemination of results. Research Methods is an introduction for future teachers to the tools and mathematics that scientists use to solve scientific problems, and the communication of that work. Students independently design and carry out: (1) a brief home inquiry, (2) a preliminary laboratory inquiry from which they could build a HS lesson, (3) a survey involving human subjects, and (4) an extension of their laboratory inquiry. The pXRF allows exciting integration of AP physics 2 content (i.e. gamma radiation, quantized energy levels) into a variety of STEM instructional projects.
Funding for this project was provided by • NSF Award #ICER-1911347, "GP-IMPACT: Improving Geoscience Education for Rural and First-Generation College Stu-

dents through a Shared-Instruments Collaboration - Bridging the High School to Undergraduate Divide for Students in Reclamation Science and Management, and
• Funds appropriated under the Hatch Act

(7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Integrating Imaging Physics into Undergraduate STEM Education

Presenting Author: Bethe Scalettar, Lewis and Clark College Physics

Additional Author | James R. Abney, Psi Star Intellectual Property LLC

Physics is a notoriously challenging subject that plays a critical and ubiquitous role in our lives. Undergraduate educators thus need new approaches that will encourage college students to study physics. We have addressed this need through the development of a novel undergraduate physics course and associated textbook that cover the principles, practice, and application of prominent biomedical imaging techniques (i.e., light microscopy and medical imaging) and explore their extensive connections to physics. We chose to focus on imaging because it is a powerful, ubiquitous scientific tool that has strong foundational ties to physics. Imaging also arises frequently in everyday life, so students are interested in the topic and appreciate its importance. The physical foundations of imaging can be established using approaches that range from purely conceptual to highly theoretical. We use a combined conceptual and theoretical approach that is enthusiastically received by students majoring in all STEM disciplines. This success suggests that other institutions also would profit from offering a course focused on biomedical imaging. Here we describe the course content, including highly popular hands-on activities, to help pave the way for other educators who are interested in teaching a similar course.

(7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Metacognition, Help Seeking, and Overcoming Research Obstacles

Presenting Author: Philip Reutter, Physics Department, Le Moyne College

Additional Author | Dina Zohrabi Alaee, School of Physics and Astronomy, RIT

Additional Author | Benjamin M. Zwickl, School of Physics and Astronomy, RIT

This project examines how undergraduate research students deal with times when they feel little progress is being made. What kinds of things cause students to get stuck in their research? What steps do they take to get "unstuck"? We consider two types of approaches when it comes to progression of the research plan: internal and external. Self-directed, internal learning is related to metacognition, which is typically defined as thinking about thinking, or more accurately, the process of reflecting on and directing one's own thinking. The external approach involves aid from other people, such as a labmate or a research advisor. We conducted 10 interviews with students doing summer research projects. During the interviews, students discussed their thought processes and approaches while doing research. We will discuss themes that emerge from this data regarding obstacles and how students try to overcome them. Ultimately, the research should help students identify obstacles in their research and find productive ways to overcome them.

(7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | COMSOL Multiphysics Mdeling for Thermally Efficient Windows

Presenting Author: Agrim Gupta, Ramapo College of New Jersey

Additional Author | Alex Sikiric, Ramapo College of New Jersey

Additional Author | Clara Love, Ramapo College of New Jersey

Additional Author | Daniela Buna, Ramapo College of New Jersey

Additional Author | Narayan Pokhrel, Virginia Tech

Solar films are one of the best devices for increasing the energy efficiency of a window by decreasing the radiative heat load. Solar films are made by coating a thin polyethylene terephthalate (PET) film with an optically active layer that blocks ultraviolet radiation. Unlike other solutions, solar films have the advantage as they can be retrofitted onto existing windows without the need for costly window replacements. This preliminary study investigated the feasibility of modeling complex window/solar film systems with Comsol multiphysics. The solar films that we chose to model are made by Eastman Performance Films LLC. We chose their LLumar architectural window film designed to block >99% of UV radiation while transmitting 89% of visible light. To incorporate this kind of solar film in our model we had to research the physical constants. These constants include finding the density, thermal conductivity, electrical conductivity, relative permittivity, relative permeability, and heat capacity at constant pressure. After successfully modeling the solar film, future avenues of research include ways to optimize existing systems as well as investigate new combinations of geometries and materials to increase the efficiency of these windows.

(7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Service and Learning in the Intersection of Physics & Public Policy

Presenting Author: Curtis Asplund, San José State University

I present on an upper division undergraduate course I created: "Physics & Public Policy." I teach about the role of physicists in influencing, reforming and/or creating public policies. Topics include electrical energy, nuclear power, nuclear weapons, and climate change. Because of the real-world impact of these topics on people's well-being, I teach ethical frameworks and how they may be applied to policy questions. For many students, it is their first exposure to ethical theory and to thinking critically about the role of scientists in society. I also include a Service Learning component in the course, wherein students volunteer with a local non-profit that helps low income residents with their electricity bills. Through discussions, reflective writing, and class presentations, they explore how their service relates to the rest of the course content. I present my teaching methods and results and discuss possibilities for exposing more students in physics courses to ethical & societal thinking and to Service Learning, as ways to prepare them to engage with pressing local and global problems.

| Contributed Talk (12 Minutes) | Dice Designing: An Innovative Approach to Visualize States in a 2-State (and Beyond) Quantum System

Presenting Author: Abdorreza Samarbakhsh, Middle Tennessee State University

In this work we present how to visualize different pure states and ("superposition") states in a 2-state quantum system with designing different dices in shape and color/number. Later we will expand the method in order to be able to represent a 3-state, 4-state quantum system. This approach can be used as a new technique to help comprehending the meaning of a "sates" for those who are interested to learn quantum system.

| Poster Presentation Traditional | Radius of the Earth from Photo of Two Distant Bridges

Presenting Author: Clinton Lewis, West Valley College (retired)

This is the story of how serendipity, persistence, and a modeling approach lead to an accurate radius of the Earth. An unusual photograph through a telescope of two distant San Francisco bridges, one close, one far, shows the curvature of the Earth. The more distant bridge is clearly lower in the water of SF Bay than a Flat-Earth calculation would indicate. Three models deliver successively better results. Measurements on this photo, bridge dimensions, and a calculation results in an estimate of the radius of the Earth surprisingly accurate!

| Poster Presentation Traditional | NASA HOEE Starshade Undergraduate Challenge

Presenting Author: Janessa Slone, American Institute of Physics

Additional Author | Brad Conrad, American Institute of Physics

Additional Author | John Mather, NASA

The NASA HOEE Starshade Challenge is intended for Undergraduate Students in Engineering and Physics/Astronomy and promotes various skills they've learned throughout their college career. Students have the opportunity to showcase their level of mastery in their degree and learn to problem solve and think critically to design and produce an ultra-low mass Starshade. Carefully, a Starshade can be constructed and positioned to block only the bright star's light but allow exoplanet light to reach the telescope, helping NASA Scientists characterize exoplanets further. Using elements of engineering and physics students will contribute to a developing project in this once an a lifetime challenge.

Beyond Introductory Physics: Quantum Posters

H801 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Clicker Questions as Instructional Tools to Teach Measurement Uncertainty in Two-state Systems

Presenting Author: Peter Hu, University of Pittsburgh

Additional Author | Yangqiuting Li, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Research-validated clicker questions comprise an easy-to-implement instructional tool that can scaffold student learning while formatively assessing students' knowledge. We present findings from the development, validation and implementation, in consecutive years, of a Clicker Question Sequence (CQS) on measurement uncertainty as it applies to two-state quantum systems. This study was conducted in an advanced undergraduate quantum mechanics course, in both an online and in-person learning environment. Student learning was first assessed after receiving traditional lecture-based instruction on relevant concepts, and their performance on it was compared with that on a similar assessment given after engaging with the CQS. We analyze and discuss similar and differing trends observed in the two modes of instruction.

H803 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Flexible Online Resources for Teaching Quantum Mechanics

Presenting Author: Steven Pollock, University of Colorado Boulder

Co-presenting Author | Gina Passante, California State University Fullerton

Additional Author | Giaco Corsiglia, University of Colorado Boulder

Additional Author | Homeyra Sadaghiani, California State Polytechnic University-Pomona

Additional Author | Bethany R Wilcox, University of Colorado Boulder

As part of a broad project to improve the teaching and learning of undergraduate quantum mechanics, we have developed a suite of instructional materials that are easy to implement into a variety of instructional contexts. These materials are freely available online and are modular, adaptable, and include clicker questions, sample lecture notes, tutorials (both in person and online), preflights, homework and exam questions, as well as an end-of-course conceptual survey. Our newly designed online tutorials allow for many of the benefits of tutorials without taking up valuable class time. They provide dynamic feedback to students and can be assigned for out-of-class use either as individuals or for groups. Stop by our poster to see examples of all these materials and chat with us about what might work best for your instructional setting.

H809 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Conceptual Metaphor and Linguistic Difficulties in Learning Quantum Mechanics

Presenting Author: Amy Lytle, Franklin & Marshall College

Additional Author | Joshua Slager, Franklin & Marshall College

Physics learners are confronted with many new, frequently abstract, concepts as well as new technical language that describes them. Making sense of abstract ideas, like physical states or fields, is influenced by the conceptual metaphors instructors use when speaking about them. Students also construct understanding about the ontology of physical concepts through clues in the functional grammar used. Sense-making through interpreting language is particularly relevant to connecting the mathematical abstraction of theory to the concrete physical phenomena. Quantum mechanics presents a particular challenge to learners; not only is the theory an abstraction of the physical phenomena, but the physical phenomena themselves are outside of human concrete experience. Previous work has shown that students have difficulty with concepts such as quantum states, observables, results of measurements, and their mathematical counterparts. Since these concepts are foundational in quantum theory, a conceptual understanding of their uses and ontological distinctions is essential. We present results of an exploratory study to examine the conceptual metaphors and ontological categorization that students and instructors use when speaking about these concepts in the context of a spins-first curriculum. Our goal is to elucidate language-based difficulty with learning quantum mechanics concepts.

H811 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Student Perspectives about Seeing Quantum Effects in Experiments

Presenting Author: Victoria Borish, University of Colorado Boulder, JILA

Additional Author | Heather Lewandowski, University of Colorado Boulder, JILA

Quantum mechanics is a field often considered very mathematical and abstract. To make quantum more concrete, some instructors expose their students to fundamental quantum phenomena in an experimental setting. This can be done in undergraduate instructional labs with a sequence of quantum optics experiments referred to as the single-photon experiments. Here, we present results from an interview study about what it means to both instructors and students to see quantum effects in experiments. Focusing on the single-photon experiments, we find that students believe they are observing quantum effects and achieving related learning goals. Although it is not possible to see the quantum phenomena directly with their eyes, students point out different aspects of the experiments that contribute to them observing quantum effects. There is also variation across student achievement of related learning goals, ranging from many of the students being excited about these experiments and making a connection between the mathematical theory and the experiment to only some of the students seeing a connection between these experiments and quantum technologies. This work can help instructors consider the importance and framing of quantum experiments.

H813 (7:00 to 8:00 PM) | Poster Presentation Traditional | Spin Angular Momentum for Undergraduates

Presenting Author: Robert Close, Clark College (retired)

There are two types of momentum associated with waves: the "canonical" momentum that is proportional to the velocity of the material and the "field" or "wave" momentum associated with force and propagation of energy in the form of waves. It logically follows that there are also two corresponding types of angular momentum in continuous media: "intrinsic" or "spin" angular momentum associated with rotations in the medium and "wave" or "orbital" angular momentum associated with wave propagation and torque. Spin density is uniquely defined from a Helmholtz decomposition of momentum density as the field whose curl is equal to twice the incompressible component of momentum density. It is related to the usual "moment of momentum" density through integration by parts. Local torque density and force density are similarly related. Equating torque density with the motion-compensated time derivative of spin density is equivalent to stating that total angular momentum is locally conserved. A wave equation is derived for spin density in an elastic solid, and its relation to the Dirac equation of relativistic quantum mechanics is explained.

I905 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | SUPER Cohort Program: Student Wellbeing

Presenting Author: Peter Sheldon, Randolph College

Additional Author | Meghan Halbrook, Randolph College

Additional Author | Sarah Sojka, Randolph College

Additional Author | Jesse Kern, Randolph College

Randolph College instituted a recruitment and retention program funded by three NSF S-STEM grants that has contributed significantly to the success of our STEM students. We have significantly increased the numbers of our science graduates, particularly in physics. This comprehensive STEM honors program is SUPER: Step Up to Physical Science and Engineering at Randolph. It includes a summer transition program, first-year living-learning community, mentoring, career services, tailored seminars, and enhanced academic support services. The newest iteration of the S-STEM grant focuses on mental wellness and inclusiveness. We will discuss the programs and services we have implemented, and will share any research results that we have about effectiveness.This project is supported by the National Science Foundation under Grant Nos. DUE-1153997, 1564970, 2029082.
Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

I907 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Willamette STEM Fellows: Improving Retention of Underserved Students In The Sciences Through Co-Curricular Support Structures

Presenting Author: Daniel Borrero-Echeverry, Willamette University

Additional Author | Cooper H. Battle, Willamette University

Additional Author | Sarah R. Kirk, Hobart and William Smith Colleges

Additional Author | Michaela Kleinert, Willamette University

Additional Author | Alison J. Fisher, Willamette University

Initiated in 2018, the Willamette STEM Fellows Program was initially funded through an NSF S-STEM grant and has since garnered substantial institutional support and investment. The program supports students throughout the sciences through four years of structured co-curricular support including first-semester living-learning communities, weekly cohort-specific classes for the first two years, dedicated secondary and tertiary advisors, funded research opportunities, leadership development, and individualized career planning as well as gap-filling scholarships. One particular focus has been the introduction of Embedded Tutors (supplemental instruction) to help improve student retention through classes often perceived as barriers to success in STEM fields like Introductory Physics and General Chemistry. This model has since been expanded to our lower-division Physics courses, across the entirety of the Chemistry curriculum, and is increasingly being used throughout our institution. Following the graduation of our second cohort of students in Spring 2023, we will present an overview of our successes, challenges that we have encountered, and alterations that we have made to our program over the past 5 years.
This work was supported by the National Science Foundation through grants # DUE-2221694 and # DUE-1742159.

I909 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Fostering Psychological Safety in Team-based Undergrad. Physics Classrooms

Presenting Author: Isaura Gallegos, Harvard University

Additional Author | Eric Mazur , Harvard University

Collaborative teamwork is ubiquitous in generating scientific knowledge. Additionally, it is often a component of active learning strategies that are increasingly implemented in undergraduate physics classrooms (e.g. project-based learning, team-based learning, or peer instruction). Existing research suggests that classes that incorporate pedagogical practices with collaborative teamwork components have mainly positive student learning outcomes compared to direct instruction. Therefore, due to the centrality of collaborative teamwork in both the workforce and the classroom, it is crucial to investigate the conditions that best promote collaborative teamwork skills. In this presentation, I will briefly discuss the findings from a mixed-methods study of psychological safety, a construct pivotal for successful teamwork experiences in learning, in an undergraduate physics course. Although research findings motivate my interest in fostering psychological safety to enhance collaborative teamwork, the primary objective of this talk is to discuss best practices and key considerations when designing teamwork experiences.

I913 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Using STEP UP Women in Physics Lesson to Build Inclusive Classrooms and Labs

Presenting Author: Jolene Johnson, University of Wisconsin River Falls

In the US, most physics classrooms contain a low percentage of women and underrepresented minority students. In laboratories, due to the smaller number of students per section and required small group work, students of underrepresented groups can face more challenges because of increased isolation. As physics instructors, our goal is to support these students and create a welcoming environment for everyone. In this talk, I will focus on how the STEP UP Women in Physics lesson can be used both to support isolated women and other underrepresented students, and to create more equitable group work from which all students will benefit. An overview of the lesson (with possible extensions) will be given along with tips for implementing in high school, community college, and university classrooms.

I915 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Inclusion of Women in the Physics Classroom of the First Year of Engineering

Presenting Author: Santa Tejeda, Tecnologico de Monterrey

Additional Author | Manuela Ortiz, Tecnologico de Monterrey

Additional Author | Luisa Fernanda Chaparro Sierra, Tecnologico de Monterrey

Additional Author | Carolina B. Rodríguez-Garza, Tecnologico de Monterrey

Additional Author | Claudia Bautista Flores, Tecnologico de Monterrey

The inclusion of women high school students has been worked on by the STEP UP program, covering relevant topics of the inclusion of women in the Physics classroom. The communication manual "Everyday Actions" has been translated into Spanish, keeping the original objective to work with high school students. In this poster, the aim was to generate a manual version for the inclusion of first-year female students by her teacher. In order to realize that, four women physics professors analyzed and discussed the complete manual and found specific points to be reconsidered: for example, the participation of the student's parents and other significative relationships for students. As a result, we have a slightly different manual, with topics more oriented to first-year women students and a proposal of rubric at the end of it. We present this effort to get feedback and the perspective of the community.

Educational Technology Posters

F601 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Web-based, Open Source Video Analysis App for Student Experiments

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

Video analysis is a well established technique for studying motion in introductory physics. Commercial software for this purpose that runs under Windows and Mac operating systems has been available for some time [1,2]. More recently, a commercial analysis app that runs on Chromebooks has become available [3]. Unfortunately, none of these programs are free, which limits their use to classrooms in schools with sufficient financial resources to cover the cost. This poster describes a simple, free, open-source app suitable for analyzing videos that students create themselves using their smartphones. The app is written in Javascript, and runs in a browser window on Chromebooks and standard laptops. The ubiquity of smartphone video cameras lets students test their own ideas about what is important in free fall and other motion experiments. Examples include determining the acceleration due to gravity, projectile motion, and terminal velocity of a coffee filter.

[1] Logger Pro, Vernier Science Education, Beaverton, Oregon, USA.
[2] Capstone, PASCO, Roseville, California, USA.
[3] Vernier Graphical Analysis, Vernier Science Education, Beaverton, Oregon, USA.

F603 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Impact of an Angular Momentum Interactive Problem-Solving Tutorial on Student Performance

Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Kathleen Koenig, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology

Under NSF funding we have been developing and evaluating Interactive Video-Enhanced Tutorials (IVETs) which are designed to help students learn to use expert-like problem-solving strategies for college students in introductory physics. The tutorials involve web-based activities which lead students through a solution by providing guidance and feedback depending on the choices they make within the activities. This presentation will showcase one of our IVETs, namely Angular Momentum, and provide details about its design features, which involve multimedia principles of learning and research on human learning and memory, and subsequent impact on student problem-solving abilities.

F605 (7:00 to 8:00 PM) | Poster Presentation Traditional | Evolution in Student Conceptual Understanding of Energy and Momentum

Presenting Author: Alexandru Maries, University of Cincinnati

| Mary J Brundage, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

The Energy and Momentum Conceptual Survey (EMCS) is a multiple-choice survey that contains a variety of energy and momentum 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 EMCS 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 EMCS questions that remain challenging for many upper-level and graduate students. Work supported by NSF

F607 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Augmented Reality Simulations for Introductory Physics

Presenting Author: Garrett Matthews, University of South Florida

Additional Author | David Rosengrant, University of South Florida

Additional Author | Karina Hensberry, University of South Florida

Additional Author | Nancy Sharfun, University of South Florida

Additional Author | Kally Navas, University of South Florida

The research team at the University of South Florida is creating multiple augmented reality simulations that will be free for instructors. We have 3 of the 6 planned simulations created: Gravity, Forces, and Thermodynamics. In our winter workshop, we will add Magnetism, Circuits, and Optics. These simulations use a free printable cube that allows users to physically interact with it. Thus, these simulations could be used in an in person or an online format. One of the key facets of the simulations will be that users have the ability to manipulate multiple variables so that students can see the effects with real time data and or representations such as graphs or pictures. We have also supplemented the simulations with curriculum we have developed. The curriculum is grounded in the Investigative Science Learning Environment (I.S.L.E.) framework. The purpose of this presentation is to share the simulations with the physics community. In the future, we will research how (or if) these simulations can effectively be used to increase student learning in a large lecture type format. This work is being funded through an I-USE grant supported by the National Science Foundation.

F609 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Scaffolded Problem-Solving for Introductory Mechanics with STEPP

Presenting Author: Mary Urquhart, University of Texas at Dallas

Additional Author | Midori Kitagawa, University of Texas at Dallas

Additional Author | Michael Kesden, University of Texas at Dallas

STEPP, the Scaffolded Training Environment for Physics Problem-solving, is a free-to-use set of interactive instructional tools that run in a standard web browser at STEPP.utdallas.edu. Three current modules support introductory physics learning for 1D motion, 2D motion, and Newton's laws of motion. Originally designed to improve computational thinking while synergistically teaching mechanics, STEPP also provides scaffolded problem-solving support for students. To create a simulation of word problems already in their curriculum, students 1) choose a module and level, 2) decompose the problem, and 3) select the character, background, and inputs, and if the simulation shows it is ready, 4) hit run. The result is dynamically displayed animated model that can simultaneously produce color-coded graphs. STEPP has user options to display slope on graphs as well as equations, and where relevant, free body diagrams. Depending on the level and module, users can choose to display velocity and acceleration vectors and forces as part of their animations. Software calculated values can be displayed by default or hidden for the assessment mode. The design of STEPP intentionally has a low entry threshold. No prior physics, programming, or coding experience is needed!
*STEPP development was funded by NSF STEM+C Grant No. 1741756

F611 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Online Homework Systems: Helping or Hurting?

Presenting Author: Elizabeth Schoene, South Seattle College

Additional Author | Abigail R Daane, South Seattle College

Online homework systems have become a common resource for introductory physics classrooms. While the instant feedback from these programs can support learning, we questioned the correlation between our student's homework and exam scores. To explore the possible benefits of an alternative, we recently transitioned from a fully online homework system to a paper-based homework system where students submit handwritten solutions. We compared the average exam grade for each student with their average homework grade for several calculus-based introductory physics classes that either used the online system or the paper-based system. While paper-based homework may increase the workload of instructors, the results indicate that a back-to-basics approach can better align students' homework effort and performance with exam scores and overall learning.

F613 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Experimental Introductory Physics: Computational Immersion Using Maple

Presenting Author: Scot Gould, Claremont McKenna, Pitzer, Scripps

This poster reports on the outcomes of an experimental first-semester introductory physics. For the course, all mathematics was presented, and all problem-solving was performed using Maple, the computer algebra system. Maple was chosen because it is free to all students, includes a rich clickable user interface and is highly readable. Maple "code" looks like the mathematics the students have learned. The basic skillsets of using Maple were taught through a collection of ten-minute videos and associated problem sets. Each skillset was introduced when needed to solve the types of problems for the physics principle being studied. Example topics covered and/or learned using Maple included algebra, trigonometry, single-variable calculus, curve fitting and linked sets of differential equations. Homework submissions were in the form of a Maple worksheet. In addition to being able to solve realistic and complex physics problems, students learned to present their results through publishable graphs, animations, and simple "what if" applications. At the end of the semester, the majority of the students felt Maple allows them a greater opportunity to concentrate on understanding physics principles while spending less time performing the mathematical minutia that typically exists within the course.

F615 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Helping Teachers Bring Coding to Their Students

Presenting Author: Maajida Murdock, QuarkNet

QuarkNet is a 24-year particle physics outreach program for high school teachers. Workshops and online activities now include Python-based investigations of large data sets from detectors that discovered the Higgs boson as well as broader topics of weather and climate, periodic table, and plate tectonics. The professional development cycle extends to the teachers who facilitate the workshops, elevating the next cohort of teacher leaders.

Introductory Courses Posters

C301 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | The Assessment of Introductory-Physics Course by Item Response Theory

Presenting Author: SHIHONG MA, Department of Physics, Fudan University, Shanghai 200433, CHINA

Additional Author | SHU-RAN YANG, Department of Physics, Fudan University, Shanghai 200433, CHINA

It is an important means to measure the learning effect of students, educational data mining based on test results will help to understand the quality of course teaching. This studying takes the university physics course and teaching physics-experiment course as an example. Based on the three-parameter logical model in item response theory (IRT), the difficulty, discrimination and guessing coefficients of the three types of questions: multiple choices, fill-in-blanks and calculation, were calculated in different teaching classes. The analysis results showed that the guessing coefficients of fill-in-blanks could reflect the quality of class teaching effects. Our research shows that with either the box plot or the cluster analysis method, the guessing coefficients of filling-in-blanks can be used to detect the outlier classes. By the means of accurate teaching quality management, the overall quality of teaching will be improved.

C303 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | A Case of Resource Building in Introductory Physics with ACORN Tutorials

Presenting Author: Al Snow, University of Washington, Seattle

Additional Author | Paula Heron, University of Washington, Seattle

Additional Author | Amy Robertson, Seattle Pacific University

Additional Author | Lisa Goodhew, Seattle Pacific University

Additional Author | Lauren Bauman, University of Washington, Seattle

Resource theory depicts resources as dynamic, context-dependent "pieces of knowledge," and defines learning as building from students' conceptual resources. Our team has developed research-based instructional materials meant to elicit and build on common conceptual resources for understanding circuits. We refer to these as ACORN Physics tutorials, for Attending to Conceptual Resources in Physics. We will use a classroom video example of students working through these resource-oriented instructional materials to explore how one group of students, using ideas about circuits that we characterize as conceptual resources, construct a model for what makes a lightbulb light.

C305 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Investigating Layers of Abstraction in Gestures in Physics Collaborative Problem Solving

Presenting Author: Cagla Zirek, University at Buffalo

Additional Author | Virginia J. Flood, University at Buffalo

Additional Author | Benedikt W. Harrer, University at Buffalo

In collaborative problem-solving activities, students communicate and develop their ideas through many modes, using external tools like whiteboards and laboratory instruments for modeling and experimentation. Paying attention to gesture is especially useful when investigating the nature of the students' understanding of physics phenomena. We examined gestures performed by groups of 3-4 students solving problems about mechanical energy from the Collaborative Learning through Active Sense-Making in Physics (CLASP) curriculum in an introductory, algebra-based undergraduate physics course. We show how students' gestures about physics phenomena incorporate both concrete and abstract forms of iconic representation. Concrete iconic gestures depict objects and actions that make up the physical system, like illustrating tossing a ball. Abstract iconic gestures depict disciplinary forms of representation such as coordinate systems. By blending these two types of representational gestures, students laminate layers of information together to support their collaborative problem-solving discussions. Becoming more aware of and making sense of how students use gesture for sense making can aid educators in assessing and building on students' understanding of physics.

C309 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Equitable Approach to Introductory Calculus-based Physics Courses Focused on Problem Solving

Presenting Author: Eric Burkholder, Auburn University

A major challenge with calculus-based physics 1 is the range of physics backgrounds. This level of preparation is strongly predictive of a students' performance and hence can amplify K–12 educational inequities. Here, we present a novel introductory course design to address this equity challenge. The design and implementation are based on the concept of deliberate practice as applied to learning real-world problem solving. The problems used in the course and their solutions have little resemblance to what students encounter in high school physics, thereby reducing the dependence of course performance on high school physics preparation.The students who took the course learned the physics content knowledge they needed for future courses, particularly in engineering, and their problem-solving skills improved substantially. Furthermore, their course performance had much less correlation with their incoming physics preparation than was the case for the outcomes from the traditional Physics 1 courses at both institutions: in one case the correlation dropped from r=0.62 to 0.14, and on the other case the correlation dropped from r=0.56 to 0.26. These findings suggest this course design can be a more equitable version of the traditional Physics 1 course, and hence particularly beneficial for marginalized students.

C311 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Group Activities to Synthesize Physics Understanding

Presenting Author: Matthew Olmstead

Over the years, I have included different games and activities to help students better understand physics. Some of these focus on understanding a current topic or problem solving strategy while others have been used as a review tool, and still others have focused on looking at these concepts from a different perspective including pictures and language. The goal of this poster is to highlight several of the activities I have implemented in the past year including one focused on saying the same word as your partner, another on using different words to allow a teammate to guess the clue word, and a third on using a single word to guess a range from low to high.

C313 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Assessment of Students' Skills in Physics in ISLE Courses at Rutgers - Newark

Presenting Author: Joshua Rutberg, Rutgers University - Newark

Additional Author | Nicolas Viot, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Patrick Makowski, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

In Fall 2019 the Rutgers - Newark physics department reformed all of their introductory physics courses using ISLE. We describe how we assess students' skills in physics in weekly quizzes from the Fall 2022 semester on mechanics. Students took quizzes in class and had the opportunity to resubmit quizzes. This study presents data from students' first quiz submission. Twelve skills were assessed during the semester, with most skills assessed twice and some up to four times. We present student work demonstrating different levels of proficiency and share overall trends in the development of these skills.

C315 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | The Effects of Active Learning on Students' Sense of Belonging and Academic Performance

Presenting Author: Yangqiuting Li, Auburn University

Additional Author | Eric Burkholder, Auburn University

Prior research has shown that active learning can enhance students' academic performance in physics courses. However, very few studies have examined the effect of active learning on students' sense of belonging in physics classes. In this study, we analyzed data from an introductory physics course at a large public research university, taught independently by three instructors, one of whom employed research-based active learning strategies. Our analysis revealed a significant decrease in students' sense of belonging in traditionally taught classes, while students in the active learning class experienced a slight improvement in their sense of belonging. Moreover, we observed a significant gender difference in students' sense of belonging in both active learning and traditional classes at the beginning of the course, which were closed by the end of the active learning class but not in the traditional classes. Additionally, the active learning class positively impacted students' academic performance, as measured by final exam and diagnostic test scores, with the effect partially mediated by sense of belonging. Our findings suggest that active learning classes with intentional efforts to create inclusive environments have the potential to enhance students' sense of belonging and academic performance.

C317 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Student Perceptions of Interactive Multimedia in Learning Physics Concepts

Presenting Author: Rudra Kafle, Worcester Polytechnic Institute (WPI)

Multimedia communication refers to more than one medium of communication. For example, if we consider a textbook, it has some text at minimum. It may also have pictures, graphs, tables of data, and so on. In the modern era of digital technology, its span has widened to audio and video recordings and even interactive animations. We have been using interactive multimedia in teaching physics concepts in college physics courses. I will present student perceptions of such interactive multimedia in learning physics concepts.

C319 (7:00 to 8:00 PM) | Poster Presentation Traditional | Guided Inquiry for Calculus-Based Introductory Electricity and Magnetism

Presenting Author: Kara Beauchamp, Cornell College

Researchers have found that when students spend class time actively engaging with course material instead of passively listening to lectures, student understanding of the course material is improved. Process Oriented Guided Inquiry (POGIL) is an effective method of active learning, in which students work through guided inquiry materials in small groups, and which focuses on students communicating and explaining concepts to peers. While many active learning methods have been developed for physics, POGIL activities have not been developed for calculus-based physics classes. In this poster, I present a few preliminary guided inquiry materials I developed and used for a calculus-based introductory electricity and magnetism class. I had 23 students in the class, with interests in engineering, chemistry, and physics. Louis Deslauriers, Ellen Schelew, and Carl Wieman, v. 332 Science, 2011 and Louis Deslauriers, Logan S. McCarty, Kelly Miller, Kristina Callaghan, and Greg Kestin, Proceedings of the National Academy of Sciences, v 116, 2019

B201 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Breaking Reality: Escape the Arctic with Climate Knowledge

Presenting Author: Danielle Buggé, ASRC Federal/ NASA Goddard Space Flight Center

Co-presenting Author | Elana Resnick, Rutgers University

As the climate crisis grows ever more pressing for our planet, the importance of climate science in the K-12 classroom needs to expand beyond climate-specific curricula or piecemeal lessons. The relevance of climate change to our students' lives should increase their motivation to learn about a seemingly disconnected topic from physics. To engage our learners in these important global issues, we created an Investigative Science Learning Environment (ISLE) approach digital escape room game that transports students to a sinking remote Arctic research facility. The storytelling narrative of escape rooms is one way to incorporate climate change into the high school physics curriculum. We piloted this escape room with high school-age students (14-18 years old) over several class periods at the end of their first-year physics course. Overall, the reception to the game was positive and the students were able to make connections between their constructed physics knowledge and the provided climate science data. This poster provides an overview of the game, how it aligns with the NGSS Physics and Climate Change DCIs, Science Practices, and Cross-Cutting Concepts, as well as how gameplay led to increased, student-initiated, conversations about climate change.

B203 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Breaking Down Barriers: Building Middle and High School Non-Physics Teachers' Confidence and Competence in Teaching Physics

Presenting Author: Carmen del Pilar Suarez Rodriguez, Academic Coordination South Huasteca Region, Autonomous University of San Luis Potosi

Additional Author | Marcelo Caplan, Science and Mathematics Department, Columbia College Chicago

Physics is a complex discipline and much more difficult to teach if the teacher does not have a solid background in the area. This observation is valid and established among elementary education teachers in Mexico and Latin America. For this reason, it is essential to design strategies to change the teacher's thinking and perceptions about the teaching of physics and its experimentation. To provide teachers with resources and tools that favor the learning of physics, a 40-hour remote lead course was designed, with synchronous sessions through videoconferences and asynchronous sessions placed in an LMS. Participants could explore and incorporate STEM education's approach in their environment, classroom, or informal education settings through these activities. Activities were oriented to promote physics content, such as Newton's laws, the physics of sound, mathematical modeling of physical phenomena, and especially, the development of experimental research-based exploration. In the first implementation, 45 teachers completed the course. Later was implemented in similar versions at several institutions in Peru, Colombia, and Mexico and has served as the basis for designing a teacher training program in STEM. The results of the course implementation and the impact on the participating teachers are presented and discussed in the paper.

B205 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Dimensional Analysis: A Novel Way for Students to Understand Physics Equations

Presenting Author: Michael Peterson, Triangle Math and Sci Academy

Dimensional analysis is a powerful tool for simplifying complex problems and understanding the underlying physical relationships between different quantities. Accessible to all physics students from Honors Physics to Advanced Placement C Electromagnetism, dimensional analysis helps students understand the physics behind equations. In this study, Advanced Placement students (N=27) used dimensional analysis throughout the course to derive equations, determine missing variables, and develop hypotheses for experiments. The results from a post-course survey suggest students found dimensional analysis easy to learn and implement. Students also believe that it significantly contributed to their understanding of physics. Further studies are needed to confirm and extend these findings.

B207 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Lewis University's PhysTEC Recruiting Grant Outcomes

Presenting Author: Joseph Kozminski, Lewis University

Additional Author | James Hofmann, Lewis University

Additional Author | Dorene Huvaere, Lewis University

With support from a PhysTEC recruiting grant, Lewis University has developed and implemented a number of recruitment strategies to grow its physics teacher preparation program over the last three years. We added a third pathway to teacher licensure – a five-year program leading to a BS or BA in Physics and an MA in Secondary Education. We have collected teacher salary and economic data in the Chicagoland area and incorporated these into a website, marketing materials, and separate presentations for faculty and students, based on Get the Facts Out resources. We have been doing internal recruiting throughout the grant period but were only able to start reaching high school and community college students in the last year due to pandemic-related challenges during the first two years. This poster will discuss our grant activities, including our successes and challenges, and our plans for post-grant physics teacher recruiting.
This work is supported by the National Science Foundation and the Physics Teacher Education Coalition (PhysTEC) under grant no. 1707990.

B209 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Quantum Computing in the High School Classroom

Presenting Author: Casey Gymrek, The Coding School

Bring emerging technology opportunities to your students! In this session, The Coding School will discuss how schools and students can learn and engage with emerging technologies like quantum computing and artificial intelligence through our free school partner program.

B211 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Hands-on Activities to Model Exponential Functions

Presenting Author: Maajida Murdock, Morgan State University; Randallstown High School

Students engaged doing two hands-on activities grounded in real-world applications. Through inquiry, students are modeling to study the occurrence of physical phenomena. With guided questions, students used mathematical modeling skills to contextualize the exponential function by a pattern from their data and technology, Desmos, to manipulate the data. Students also used their data to determine a best-fit equation and to calculate the percent error when comparing their experimental data to the theoretical data.

Labs/Apparatus Posters

D401 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | New 3D Prints for High School Physics Investigations

Presenting Author: Dylan Fedell, Palisades School District

In this presentation, I will share two new 3D printed devices that I have created for use in the high school physics classroom. I created these devices while developing novel lab investigations where the materials involved were either nonexistent or too expensive. The featured creations will include a Cavendish device for calculating G and a simple device used to investigate Newton's third law. During the talk, I will outline the hardware and software I use, discuss each device's use in teaching physics investigations, and depict their use in the classroom.

D403 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Introductory Physics Lab Activity Suite for Instilling Professional Engineering Practices

Presenting Author: John Walkup, Oklahoma State University - Stillwater, OK

Co-presenting Author | Roger Key, California State University, Fresno

Co-presenting Author | Joseph White, California State University, Fresno

PROPELLAS (Professionalism in Physics and Engineering Laboratory Learning Activity Suite) is a comprehensive suite of laboratory activities for high school or university physics to advance their learning across a broad range of career-readiness skills. Traditional laboratory activities serve primarily to support physics lecture content, with many of the activities aimed at verifying laws and relationships found in introductory physics textbooks. PROPELLAS activities, on the other hand, elevate science and engineering professionalism to the central role. Physics academic topics play a secondary role as vehicles to drive student learning in lab design, error analysis, communication, statistical reasoning, and creative thinking. Team members have developed the bulk of activities for the first semester of introductory physics centered on mechanics. PROPELLAS features lab activities explicitly targeting the development of (1) team-based brainstorming, (2) process planning, (3) troubleshooting, (4), honesty and ethics, (5) error minimization, (6) academic vocabulary development, (7) industrial quality control, (8) data-driven decision making, (9) estimation strategies, and (10) professional communication skills.

D405 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Analysis of the Current through a Diode with a Series Resistance Using the Lambert W function

Presenting Author: Alan DeWeerd, University of Redlands

Experimental measurements of the current through a diode in series with a resistor as a function of the applied voltage are analyzed using an exact solution in terms of the Lambert W funciton. Diode parameters are extracted from current-voltage data.

D407 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Student Decision Making in the Undergraduate Laboratory Program

Presenting Author: Daniel Trojand, University of New Brunswick

Additional Author | Benedict Newling, University of New Brunswick

Additional Author | Mark Hirschkorn, University of New Brunswick

We've investigated the progression of undergraduate physics students through their undergraduate lab program. Prompted by changes made to our introductory labs, from verification experiments to structured inquiry-based experiments with a focus on lab skills, we collected data in the two succeeding lab courses to gain insight into our students' habits and behaviours in the lab environment. Analysis and coding of students' E-CLASS scores, lab notebooks, and lab reports were used to inform interview prompts. Two rounds of interviews were conducted and coded, and then comparisons and contrasts were made between several data types. Results indicate that students require explicit instruction and practice for skills and behaviours to persist when those prompts are removed; the timeline for the persistence each of those skills and behaviours are different. We found that even senior students' mental model of experimental physics is lacking some key components and is in the early stages of development. Furthermore, students can only access their mental model on specific prompting. Data taking plans are not considered in the planning stages of an experiment, and students are reluctant to record and communicate their work even after identifying the importance of communication.

D409 (7:00 to 8:00 PM) | Poster Presentation Traditional | Using an Electric Field Mill in Physics II Lab--Some Positives and Negatives

Presenting Author: Clifton Murray, University of New Mexico--Valencia Campus

An Electric Field Mill, traditionally used to measure atmospheric electric fields, has been modified for student use in Physics II Lab. To date, the mill readily shows the direction of fields produced by static charges, and also the fall-off of field strength with distance from those charges. Using it to confirm the relation E = kq/r^2, however, has proven to be more challenging.

D411 (7:00 to 8:00 PM) | Poster Presentation Traditional | Making NMR Resonate with Students: Integrating NMR into the Undergraduate Science Curriculum

Presenting Author: Merideth Frey, Sarah Lawrence College

Additional Author | Colin Abernethy, Sarah Lawrence College

Additional Author | David Gosser, City College of New York

Despite the prevalence of nuclear magnetic resonance (NMR) as an essential research tool across a wide variety of STEM fields, there has historically been an inequality of access to this important piece of laboratory equipment due to its high cost and maintenance requirements. Fortunately, the recent development of inexpensive benchtop NMR spectrometers offers great opportunities for predominantly undergraduate institutions to give their students relevant hands-on learning and research skills with this essential tool in the modern STEM workforce. 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 are currently developing and testing curricular materials consisting of twenty-five lab modules and associated instructional guides and online resources. In the future, we hope 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!

Physics Education Research Posters

PER301 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Assessing Computational Thinking Attitudes in the Physics Classroom

Presenting Author: James Newland, Bellaire High School/University of Houston

If physics teachers are going to use computational thinking (CT) in their classrooms, research is needed surrounding students' CT knowledge, attitudes, and beliefs. The Computational Thinking in Science Attitude Scale (CTSAS) was designed to assess changes in students' CT knowledge, attitudes, and beliefs when using computer programming in a physics course to model phenomena. Here the author presents preliminary results about the CTSAS instrument and ways to improve assessing CT constructs in students. The CTSAS was piloted in the physics classroom before and after students completed coding activities in physics modeling phenomena. The use of other existing instruments meant to assess the knowledge, attitudes, and beliefs of students using computer programming in computer science courses will also be discussed.

PER303 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | The Tools Necessary to Link Mixed-Methods Data Sources Sources: An investigation of Students' Self-efficacy

Presenting Author: Dena Izadi, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

The development of a student's Self-efficacy (SE) is complex and limited research has investigated how SE changes over time and what particular events best support building SE for undergraduate students. SE is traditionally measured by distal accounts of students' experiences through interviews reflecting back over experiences. The advent of Experience Sampling Method (ESM) data collection in self-efficacy raises questions about how to get more proximal reflections. Our team has been running a mixed-methods study examining how SE changes using the ESM survey data combined with daily qualitative journal prompts. In this presentation, we use a qualitative lens to investigate how students' responses to the daily journal prompts correlate with their ESM survey responses. Here, we will discuss the methodology and tools necessary to link the quantitative data source with the qualitative data source in order to understand students' experiences in higher education.

PER309 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Using Curricular Analytics to Transition from Curricula to Degree Plans

Presenting Author: Amanda Nemeth, West Virginia University

Additional Author | John Hansen, West Virginia University

Additional Author | John Stewart, West Virginia University

Heileman et al. developed a methodology for quantifying the complexity of program curricula. They propose that curricula that are less complex are more effective at retaining students in college and preparing them for careers than curricula that are more complex. This methodology focuses on the curricula of a program (the course requirements and pre-requisite structure) but is insensitive to how the courses are laid out in the form of a degree plan. There may be some course combinations within a semester that have a negative impact on a student's progression through a given plan of study which are not properly characterized by the complexity of the curriculum. This study examines how curricula interact with degree plans to modify the complexity experienced by students in an introductory physics program.

PER311 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Broadening Student Learning through Facilitation of Informal Physics Programs

Presenting Author: Carlee Garrett, Texas A&M University

Additional Author | Tatiana Erukhimova, Texas A&M University

Additional Author | Jonathan Perry, University of Texas

Additional Author | Jonan Donaldson, Texas A&M University

Student learning at the university level can occur in a variety of settings, both formal and informal. Research has shown that retention of knowledge is enhanced when students teach, or intend to teach, material related to their learning. In this study, we explore the styles of learning that students engage in through informal physics programs, also called outreach, where they frequently engage in methods of self-explanation to diverse audiences. To measure impacts of these facilitation experiences, we utilized a student-centered investigation based on self-reported data gathered through didactic interviews with 35 former undergraduate and graduate students who worked with one or more physics outreach programs. Analysis centered on student perceptions of their learning and understanding of physics concepts, confidence in their knowledge, and how those constructs related to their engagement with members of the public through outreach programs. Results of a semantic network analysis will be presented.

PER313 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | PhysPort Toolkits or Starter Kits

Presenting Author: Sarah McKagan, American Association of Physics Teachers

Additional Author | Adrian Madsen, American Association of Physics Teachers

Co-presenting Author | Lauren Bauman, American Association of Physics Teachers

PhysPort.org is a website that has supported physics faculty in using research-based teaching and assessment in their classes and departments since 2009. As part of our redesign of PhysPort, we are organizing resources into "toolkits" or "starter kits", curated collections of resources around the most common questions about physics teaching that physics faculty come to PhysPort to answer. Come learn about our toolkits and tell us what toolkits you'd like to see on PhysPort.
This work was funded by NSF grant numbers 1726113 and 1726479.

ER315 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Connect with PERCOGS!

Presenting Author: Lalitasri Nandivada, PERCOGS

Additional Author | Astra Sword, PERCOGS

Additional Author | Pheobe Sharp, PERCOGS

Additional Author | Rob Dalka, PERCOGS

Additional Author | Shams El-Adawy, PERCOGS

Additional Author | Nekeisha Johnson, PERCOGS

Hi! We are PERCOGs: The Physics Education Research Consortium of Graduate Students. Join us for an interactive poster meant for making connections with others in the PER Community. This "community tree project" is an initiative made to help us strengthen and create connections in the PER community.

PER317 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Mathematics in Physics and Pre-Service Physics Teachers: Experiences and Practices

Presenting Author: Lukasz Michalak, National Resource Centre for Physics Education, Department of Physics, Lund University, Sweden

Additional Author | Kristina Juter, Centre for Mathematical Sciences, Lund University, Sweden

Additional Author | Urban Eriksson, National Resource Centre for Physics Education, Department of Physics, Lund University, Sweden

We studied a group of pre-service teachers in the physics and mathematics teacher trainee program at a university in Sweden. First, we observed how the group communicated mathematics in their cooperative solution of a physics problem taken from special relativity. Next, we conducted a semi-structured interview with the group about the role of mathematics in teaching physics in their experienced (as students) and anticipated (as teachers) learning situations. Three entities can be identified in communication of school physics, forming vertices of a ternary model: reality, theoretical models, and mathematics. In the framework of social semiotics, these vertices can be related to semiotic resources of physics. Students and teachers, by their use of semiotic resources, will emphasize different elements - vertices and links between them - of our model when handling mathematics in physics. In the case of pre-service teachers, this variation in emphasis might have implications for their future teaching practices and for teacher trainee programs. The poster will present our preliminary findings. For instance, the group tended to stay in the mathematics vertex without making frequent or strong links to the other two vertices, which - together with observed discourse imitation - might suggest insufficient fluency in the use of semiotic resources.

PER319 (7:00 to 8:00 PM) | Poster Presentation Traditional | AI-Driven Online Tutoring: Revolutionizing STEM Learning Through Modeling Human Tutor Interactions

Presenting Author: Nimish Shah, aiPlato, Inc.

Additional Author | Nimish Radia, aiPlato, Inc.

We explore the development of a groundbreaking online platform that uses artificial intelligence (AI) to simulate expert one-on-one tutoring for all STEM students, starting with Physics. The primary aim is to democratize access to expert tutoring, which boosts learning outcomes by involving pedagogical techniques of error diagnosis, targeted intervention, and proficiency mapping. The AI platform works by decomposing the complex process of human tutoring into specific interaction elements, subsequently modeling these elements for AI to learn. Techniques such as semantic similarities and sentiment analysis are used to identify these elements, ranging from remedial to probing and encouragement interactions. Through observing and learning from a multitude of human tutoring sessions, the AI builds a repository of best tutoring practices and interaction elements, generalized as well as specific to individual concepts. These interaction elements are then ingested into a comprehensive knowledge graph. Over time, the AI evolves to generate interactions that mimic successful tutoring strategies, substantially reducing the need for human tutor involvement. This pioneering approach, to our knowledge, marks the first of its kind, ushering in a new era of personalized, scalable, and universally accessible STEM tutoring.

PER321 (7:00 to 8:00 PM) | Poster Presentation Traditional | Physics of Airfoil Lift, How Texts are Incorrect

Presenting Author: Evan Jones, Sierra College

Additional Author | Don Harris, Sierra College

Additional Author | Dominic Calabrisi, Sierra College

Common errors in text treatments of wing lift and of the Bernoulli effect, Correct treatment of fluid flow based Newton's laws

PER323 (7:00 to 8:00 PM) | Poster Presentation Traditional | Investigating Academic Burnout in Undergraduate Physics Experiences

Presenting Author: Harshini Sunil, University of Colorado, Boulder

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

The term burnout is being used at increasing rates among physics students. Combined with research linking burnout to negative health and career outcomes, this increase in burnout presents a concern with respect to students' performance and retention. In this research, we will examine the experiences of undergraduate physics students in order to understand how they experience burnout. At the beginning of Fall 2022, we conducted interviews with 7 undergraduates enrolled in upper-division physics or engineering physics classes at two large research universities. We analyzed the data to determine key symptoms that students experienced who self-identified as having feelings of burnout. Following the interview study, we conducted a survey of 24 students to further investigate the symptoms of students that experienced burnout in physics. This paper presents the symptoms of the students who self-identified as burned out. The strategies used by students with lower levels of burnout are also presented.

Physics Education Research: BFY Posters

PER403 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Investigating the Quantum Mechanics Concept Assessment with Item Response Theory

Presenting Author: Jesse Kruse, University of Colorado Boulder

Additional Author | Bethany Wilcox, University of Colorado Boulder

To rigorously understand if our curricular and pedagogical choices are effective, we need tools to measure their effects. This is most commonly achieved with research-validated assessments which are tests of conceptual understanding that have undergone many rounds of revision until they meet standards for validity, reliability, and consistency. All of the research-validated assessments in physics have been analyzed using the lens of classical test theory (CTT), and a few introductory level assessments have been analyzed with the more rigorous item response theory (IRT). There is a notable lack of research on upper level quantum mechanics assessments using IRT. This poster outlines some preliminary results using IRT to analyze the Quantum Mechanics Concept Assessment (QMCA) with data from multiple universities gathered from 2018-2022. We present estimated item difficulties and person abilities for our data set, some of the limiting factors with our analysis, and how we hope to extend this work to future projects.

PER405 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | A Characterization of Existing Quantum Mechanics Assessments

Presenting Author: Molly Griston, University of Colorado Boulder

Additional Author | Jesse Kruse, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

With the rapid growth of quantum information science and technology, it is essential that we are able to build educational programs that cultivate a quantum-literate workforce. An important part of this process is assessing student learning in undergraduate quantum courses. To best support a variety of educational goals and encourage wide adoption, we aim to develop a flexible coverage assessment that both draws from existing static quantum mechanics assessments and includes new items to address quantum mechanics topics that are not currently covered in existing assessments. As an initial step toward developing such an assessment, we present a characterization of the existing quantum mechanics assessments, including a summary of the scope of current questions as well as an identification of missing topics.

PER407 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Branching Out: Measuring Model-Based Reasoning in Upper-Division Physics Labs with MAPLE

Presenting Author: Rachael Merritt, University of Colorado Boulder/JILA

Additional Author | Michael F.J. Fox, Imperial College London

Additional Author | Heather J Lewandowski, University of Colorado Boulder/JILA

Many undergraduate physics labs have students engage in modeling, the iterative process of constructing, testing, and refining models of experimental physical and measurement systems. Model-based reasoning is an important skill for undergraduate physics students to develop. Lab courses, particularly upper-division courses, provide students with the opportunity to develop their modeling skills. The Modeling Assessment for Physics Laboratory Experiments (MAPLE) is a research-based assessment instrument designed to measure student proficiency with modeling in experimental physics in upper-division electronics and optics courses. The MAPLE surveys consist of two parts. Part 1 is a 'choose your own adventure' activity which probes students' larger-scale approaches to modeling. Part 2 uses coupled multiple response questions to examine students' modeling competency and reasoning. Assessing students' modeling proficiency and growth is valuable to instructors for informing course development and improvement.

PER409 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Shared Resources in Student Problem-Solving of Spherical Unit Vectors in Upper-Level E&M

Presenting Author: Brant Hinrichs, Drury University

Additional Author | Ying Cao, Drury University

We're interested in ways that students collaborate to solve conceptual physics problems in the context of spherical unit-vectors in upper-division E&M, especially ones that are difficult for individuals to solve, but which small groups are more successful at. Using a think-out-loud protocol, we interviewed students in small groups, asking them to solve together problems from this context on a large whiteboard. Using the resources framework and an emergent coding analysis of interview video, we observed one common mechanism in all three group-interviews whereby students collaborated effectively: first one student activated a conceptual resource and expressed it, then another student took up that idea, then finally the whole group together used that idea to move forward with the problem. In this poster, we report our method of analysis and results from one group interview to illustrate a resource activated and used in this way, which we call a shared resource.

PER411 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Predicting Upper-level Course Outcomes Using Bayesian Networks

Presenting Author: John Hansen, West Virginia University

Additional Author | John Stewart, West Virginia University

Physics students' success in completing physics programs is highly dependent on how successful they are in their physics courses. Effective advising of students on which physics courses to take and when to take them is a crucial responsibility of physics departments as they strive to increase student success. The identification of which students are at risk of failing a particular course before enrolling in a course would allow departments to make informed decisions as they advise undergraduates. This study used Bayesian networks to visualize the correlations between final grades in introductory physics and mathematics courses and upper- level physics courses and predicted upper-level physics course outcomes based on the identified correlations. Decision threshold tuning was used to maximize the models' effectiveness in predicting both successful and unsuccessful outcomes and, as a result, Bayesian network models proved to be effective in identifying at risk students in upper-level physics courses.

PER413 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Developing Multiple Representation Learning and Assessment material for Introductory Quantum Computing

Presenting Author: TUNDE KUSHIMO, SOUTHERN METHODIST UNIVERSITY

Additional Author | Beth Thacker, beth.thacker@ttu.edu

Quantum Information Science and Quantum Computing as interdisciplinary fields cut across information science, computer science, mathematics, physics, chemistry, and electrical engineering. These rapidly evolving fields require new and innovative teaching and assessment techniques to effectively convey concepts to students and assess their understanding. This work is a follow-up on our previous research, Investigating students' strengths and difficulties in quantum computing, where we identified some students' strengths and difficulties. In this work, we explore the use of multiple representations, such as visualization, simulations, and mathematical calculations, to improve students' comprehension and retention of quantum computing concepts. We present some sample quizzes and problem sets that can be used to evaluate students' understanding. This work aims to inform the development of effective instructional strategies in the rapidly growing field of quantum computing education.

PER101 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | A Framework for Integrating Energy and Equity in High School Physics Instruction

Presenting Author: Rachel Scherr, University Of Washington Bothell

Additional Author | Trà Huynh, Western Washington University

Additional Author | W. Tali Hairston, Equitable Development LLC

Additional Author | Kara Gray, Seattle Pacific University

An integrated energy and social justice perspective can support high school physics teachers in integrating equity and justice into their energy instruction. We present a pilot framework that combines scholarship on equity in science education with high school physics teachers' actions to integrate equity into their physics teaching. Five approaches to equity are represented: access, achievement, identity, power, and justice. Considering this range of approaches can support teachers and teacher-educators to organize their efforts and stretch their thinking. We are in the process of further articulating and refining this framework based on our data of physics teachers' equity efforts in real classrooms.

PER103 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Investigating Experiences of Women in Color in Physics and Astronomy

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

This research focuses on the experiences of physics and astronomy graduate women of color. We conducted semi-structured, empathetic interviews to understand their experiences in their graduate program and how they navigate the physics department at large research university, which is a primarily white institution (PWI). The interviews are guided by critical race theory (CRT). We use CRT to examine how racial identities play a role in the obstacles faced by these women, including interactions between peers and faculty members.

PER105 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Women Have Lower Physics Self-efficacy Controlling for Grade Even in Courses in Which They Outnumber Men

Presenting Author: Sonja Cwik

Additional Author | Chandralekha Sinhg

Societal stereotypes and biases pertaining to who belongs in physics and who can excel in physics can impact motivational beliefs, e.g., of women and racial and ethnic minority students in physics courses. This study investigates how the learning environment predicts male and female students' motivational beliefs including physics self-efficacy, interest, and identity at the end of year long (spanning two-semester) algebra-based introductory physics courses. These were courses at a large university in the US taken primarily by biological science majors many of whom are interested in health professions. Although women are not underrepresented in these physics courses, societal stereotypes and biases internalized by female students over their lifetime can still impact their motivational beliefs about physics. Our findings show gender gap in motivational beliefs favoring men. These findings can be useful to provide support and create an equitable and inclusive learning environment to help all students excel in these courses.

PER107 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | How Perception of Being Recognized by Instructors as a "Physics Person" Predicts Students' Self-efficacy and Academic Performance

Presenting Author: Yangqiuting Li, Auburn University

Additional Author | Chandralekha Singh, University of Pittsburgh

Research suggests that students' self-efficacy in physics can influence their learning, performance and career decisions. Here we discuss a study on how the perception of being positively recognized or not recognized appropriately by the instructor or teaching assistant (TA) as a "physics person" predicts male and female students' self-efficacy and performance at the end of a two-term college calculus-based introductory physics sequence. We find gender differences in students' perceived recognition, which partially contribute to the gender differences in students' physics self-efficacy and course grades. Our findings suggest that without explicit thought and action by instructors and TAs to appropriately recognize students as people who can excel in physics, the gender gaps in physics self-efficacy and course grades are likely to persist. We thank the National Science Foundation for support.

PER109 (7:00 to 8:00 PM Sunday | Poster Presentation Traditional | Tour Guide, Coach, and Gardener: Teacher's Metaphors for Equitable Instruction

Presenting Author: Delwrick Nanthou, South Seattle College

Co-presenting Author | Maria Horak, Michigan State University

Additional Author | Michelle N Brown, Penn State University

Additional Author | Abigail R Daane, South Seattle College

Additional Author | Clausell Mathis, Michigan State University

Studies show that a physics teacher's identity impacts how they teach. For teachers interested in pursuing diversity, equity, and inclusion practices in physics instruction, their identity likely informs how they conceptualize equitable instruction. We highlight three teacher identity cases from a data set of 25 interviews of secondary and university physics teachers to examine how they conceptualized equitable instruction through four domains: their conceptions of self, others, knowledge, and pedagogy. Selected teachers had distinct conceptualizations around enacting equitable instruction that we described across three metaphors: a tour guide, a coach, and a gardener.

PER111 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Supporting Minoritized Students toward a Bachelor's Degree: The Story of the Drew Science Scholars Program at MSU

Presenting Author: Rachel Henderson, Michigan State University

Additional Author | Hady Omar, Michigan State University

Additional Author | Tiana Carter, Michigan State University

Additional Author | Jerry Caldwell, Michigan State University

Additional Author | Ariel Robbins, Michigan State University

Additional Author | Angela Little, Michigan State University

The Charles Drew Science Scholars program is a STEM program that enriches a subset of students in the College of Natural Science at Michigan State University. The ultimate goal of the program is to connect students with experiences that will support them in their development as a professional in their chosen career. In this presentation, we discuss the impressive track record that the Charles Drew Science Scholars programs holds with supporting students from minoritized backgrounds in earning a Bachelor's degree in science. Overall, the program has demonstrated great success through an analysis lens of incoming preparation and graduation rates, especially for those who identify as African American/Black, Hispanic/Latinx, or Multi-Race. We highlight one element of the program, academic coaching, which directly supports their students through the required courses for completing a Bachelor's degree. Through this support structure, we see a difference in students' overall GPA for these required courses between those who are enrolled in the Charles Drew Science Scholars program and those who are enrolled in the college more broadly. These results suggest that structures such as academic coaching may be a critical element in supporting students' success toward earning a Bachelor's degree in science. This work was supported in part by the National Science Foundation (#1742381).

PER113 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Planning for Participants' Varying Needs and Abilities in Qualitative Research

Presenting Author: Daryl McPadden, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Erin Scanlon, University of Connecticut

Additional Author | Jacquelyn J Chini, University of Central Florida

Additional Author | Harsna Chahal, Michigan State University

Additional Author | Regan Levy, Michigan State University

All people vary in their needs and abilities; however, typical research practices do not consider these variations, which likely impacts who participates in research studies. Additionally, few PER studies have even reported disability identity. Combined, this means that PER researchers typically do not seek out the experiences of disabled people and disabled people might not have access to participate in research studies. In this poster, we demonstrate how a research team can use principles from Universal Design for Learning and the Variation Planning Tool to anticipate ability expectations and create flexible options in a qualitative research study. We then demonstrate how different interview structures can impact disabled participants through a case study with three participants. Finally, we conclude with suggestions for researchers in planning their study designs. Through this example, we hope to encourage researchers to examine their own methods and offer alternative formats in their research design.

PER115 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | The State of Education in a Time of Multiple Crises

Presenting Author: Nazeer Mosley, Rutgers University

Co-presenting Author | Geraldine Cochran, Rutgers University

During the spring of 2020, concurrent with the public health crisis caused by COVID-19 and the associated economic crisis, the United States went through a period of significant civil unrest due to racialized violence against Black people. During this very challenging climate, many institutions opted to rapidly transition to courses online. Unfortunately, this change had the potential to create new inequities in education, and exacerbate preexisting inequities ones. In this presentation, we share the results of our study investigating the experiences of undergraduate learning assistants during this time. Learning assistants are in the unique position of being students, while also members of the teaching staff. As students they understand the experiences of their peers and as staff members they understand the learning goals, intended outcomes, and teaching philosophy governing the design of the course. The conceptual framework utilized in this study combines social justice and community cultural wealth.

Physics Education Research: Intro Courses Posters

PER201 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Changing Notation That Represents Force Changes How Students Say It

Presenting Author: Brant Hinrichs, Drury University

Additional Author | Dayna Swanson

Force symbols in University Modeling Instruction explicitly represent forces as detailed descriptions of interactions to facilitate (i) coordinating force with the system schema and (ii) learning force. For example, (symbol 1) represents the gravitational force by Earth on ball, where "g" represents gravitational (i.e. the type of interaction), "E" represents Earth, represents "by" and "on", and "B" represents ball. Although students are taught to say (symbol 1) as "gravitational force", audio data from student-led whole-class discussions shows that more than 40% percent of the time (symbol 1) was referred to as "force gravity" instead. Analogous results were obtained for contact force symbols as well. Because language plays such a crucial role in learning physics, several years ago, as an experiment, the notation was changed from (symbol 1) to (symbol 2) to make it more closely match how it is to be read. Student use of "force gravity" and "force contact" dropped to less than 5% with this notation switch. We show an initial comparison and contrast to how students say symbols representing energy.

PER203 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Examining the Teaching Practices of LAs in Introductory Physics Labs

Presenting Author: Michael Matos, University of Illinois Urbana-Champaign

Co-presenting Author | Jackie Vargas, University of Illinois Urbana-Champaign

Additional Author | Samuel W Engblom, University of Illinois Urbana-Champaign

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

Undergraduate learning assistants (LAs) possess a rich set of ideas about teaching, acquired through both their training as LAs and their own prior experiences as learners. In the introductory physics lab context, LAs draw upon these ideas when enacting teaching strategies. Understanding which strategies LAs see as useful can tell us much about how LAs make sense of the practice of teaching. We present the analysis of LA responses to a hypothetical teaching scenario, administered as part of the LA pedagogy course, along with a framework and coding scheme designed to identify the ideas about teaching and the nature of science that LAs draw upon. Our analysis provides insight into the common teaching strategies LAs adopt in the lab context, the ideas that ground these strategies, and how the strategies align or misalign with the goals of lab instruction.

PER205 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Why Do Students Choose the Response "Force in the Direction of Motion?"

Presenting Author: Christopher Wheatley, Physics

Physics education research has a long history of building tools to identify a wide range of common misconceptions in Newtonian mechanics, where a misconception refers to coherently and consistently applied incorrect student reasoning. There is a need for a set of tools that provide additional insight into individual misconceptions to allow instruction to be tailored to help students move to Newtonian reasoning. This project examines the common misconception that an object in motion must have a force in the direction of its motion. Students were more likely to demonstrate this misconception after being prompted by the language "force in the direction of motion" in a multiple-choice format, suggesting that either hand-drawn free-body-diagrams or a problem-specific, named force should be used instead. Students also demonstrated this misconception more often in certain contexts than others. Studying the context dependence of this misconception should help disentangle whether students are only choosing "force in the direction of motion" because it happens to coincide with the net force on an object.

PER207 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Examining the Factor Structure of the Colorado Learning Attitudes about Science Survey

Presenting Author: Dona Hewagallage, West Virginia University

Additional Author | John C Stewart, West Virginia University

Multiple studies have suggested that the factor structure originally published for the Colorado Learning Attitudes about Science Survey (CLASS) is not a good fit for the instrument. The present study extends the analysis of Douglas et al. which found a 3-factor solution. Bi-variate correlation and commonality coefficients from Explanatory Factor Analysis (EFA) are used to understand the importance of each item leading to the removal of several items. A Scree test is used to determine the number of factors. Structural Equation Modeling (SEM) is used to understand and improve the scales. Cronbach's alpha coefficients are also calculated. Four scales were identified using twenty-one items, seven items were categorized as unique items, seven items were discarded, and six items were not scored. Longitudinal Data Analysis is used to understand the time evolution of the scales.

PER209 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Evaluating Conscientiousness in Student Responses to Show-Work Exam Questions

Presenting Author: Heather Mei, The Ohio State University

Additional Author | Qiaoyi Liu, The Ohio State University

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 algebra-based and calculus-based introductory physics courses during the fall 2022 semester at a large public research university. We describe a coding scheme for "Show-Work Conscientiousness" (SWC), which include margin spacing, straight lines of work, defining variables, final answer markings, drawing diagrams, clarity and neatness, and report on preliminary findings. Further, we report on results of a brief conscientiousness survey administered to students. Finally, we describe and report on preliminary results of a hypothesized mediation model in which SWC predicts student's show-work exam question scores, and mediates the association between self-reported conscientiousness and students' exam performance.

PER211 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Can Timed Quizzes be the Answer?

Presenting Author: Duane Deardorff, The University of North Carolina at Chapel Hill

Introductory physics students are often disappointed by their performance on exams compared with their grades on homework, labs, and other formative assessments. This performance gap can be attributed to the very different conditions for these assessments: students taking in-class exams are constrained by time, only one attempt, and they cannot use other resources to help them answer questions; these constraints often do not apply to homework problems or many other low-stakes assignments. As a result, students often think they are better prepared for an exam than they really are. Instructors may encourage students to take practice tests under simulated exam conditions, but students may not hold themselves accountable to the same level as an actual exam. One way to help students prepare for exams is to provide shorter timed quizzes that can be administered online as a diagnostic tool for gauging their level of preparation. We have been experimenting with this approach and will report on the preliminary results that suggest this can be an effective way to improve exam performance for many students.

PER213 (7:00 to 8:00 PM) | Poster Presentation Traditional | The Role of Self-regulation and Metacognition in Students' Physics Learning

Presenting Author: Bijaya Aryal, University of Minnesota Rochester

In this presentation, I will describe the role of self-regulation and the quality of metacognition reflection in relation to student learning of physics concepts and problem-solving sophistication. As a measure of students' self-regulation, we examine how students plan and perform various tasks such as homework problems, lab reports, and in-class activities. To assess students' self-regulation, we examine various factors such as the time stamp of the start of the tasks, the time to complete the tasks, and number of attempts in each task. As a measure of students' sophistication in metacognition, we have collected data asking them to reflect on their study and learning techniques. I will present the qualitative relationship between students' metacognitive reflection with their self-regulation. Eventually, I will present the correlation between students' self-regulation and metacognitive reflection toward their learning of physics concepts, problem-solving performance, problem-solving approach, and attitude toward physics learning.

PER215 (7:00 to 8:00 PM) | Poster Presentation Traditional | Cognitive Sources for Phys-Math difficulties

Presenting Author: Avraham Merzel, The Hebrew University of Jerusalem

Co-presenting Author | Hadas Levi, The Hebrew University of Jerusalem, Lev Academic Center

Co-presenting Author | Yaron Lehavi, David Yellin Academic College of Education

Students exhibit difficulties concerning "physmatics" – the interplay between mathematics and physics in the context of physics education, which seldom gets attention in the learning diagnostics literature. Based on previous categorization of students' physmatic difficulties, we present the results of a diagnostic questionnaire that aims to identify possible cognitive sources for some of these difficulties. We describe possible cognitive sources based on students' paired responses to mathematical questions with and without physics context

PER217 (7:00 to 8:00 PM) | Poster Presentation Traditional | Student Affective Experiences in Introductory Physics for Life Sciences

Presenting Author: Drake Roth, Swarthmore College

Additional Author | Angelina Tjia, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Kya Butterfield, Swarthmore College

Additional Author | Stephen Hackler, Swarthmore College

Additional Author | Benjamin D Geller, Swarthmore College

Both instructor experience and an increasing amount of physics education research points to the importance of affective experiences in student learning. In order to develop methods of documenting student affective experiences, we collected brief weekly reflections in which introductory physics for life science students wrote about their sense of engagement and confidence in their ability to achieve their goals. We report preliminary findings about the connections between the experiences reported in these reflections and the curricular, pedagogical, and relational elements of the course. In particular, we describe how experiences vary by student seniority and high school physics background. We also expand upon what is learned from the reflections by triangulating with surveys and case study interviews conducted with a small subset of the class. This work is a first step toward better understanding how introductory physics for life science courses can be designed to positively shape the student affective experience.

SPS Undergraduate Poster Session

Two Year Colleges Posters

E501 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | STEM MILES: Mentoring Innovative Learning Experiences for Students

Presenting Author: Leon Hsu, Santa Rosa Junior College

Additional Author | Jan Kmetko, Santa Rosa Junior College

MILES (Mentoring Innovative Learning Experiences for Students) at Santa Rosa Junior College (SRJC) is a National Science Foundation (NSF) S-STEM funded program designed to improve the academic outcomes of high-achieving, low-income STEM students including persistence, transfer to a four-year degree granting institution, and undergraduate degree completion. The program provides students with a cohort experience with like-minded peers, a faculty mentor, workshops and a one-unit class to build career skills, and financial aid. Students are eligible for up to three years of participation in the program while at SRJC. Now at the close of the five-year grant, we examine the outcomes of this program so far, including those of students who have transferred to four-year degree granting institutions, as well as the lessons learned in implementing such a program at our two-year college. This work was supported by NSF DUE-1742635 and by Santa Rosa Junior College.

E503 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Diversity, Equity, and Inclusion Immersive Discussion Program for Two-Year Colleges under OPTYCs

Presenting Author: Kris Lui, AAPT-OPTYCs

Additional Author | Sherry Savrda, AAPT-OPTYCs

Additional Author | Dwain Desbien, Estrella Mountain Community College

OPTYCs, The Organization for Physics at Two-Year Colleges, will implement its inaugural DEI Immersive Discussion Program beginning January 2024. In this two-year program, participants will be guided through a series of activities in a two-day in-person immersive discussion to center students in DEI-effective practices. Participants will then implement strategies to better their classroom environments during the first year of the program, supported by peer mentoring and virtual workshops. Participants will be invited to a one-day training and dissemination reunion workshop in January 2025. During year two of the program, this first cohort will act as mentors to the second cohort, while disseminating their learning and strategies as a DEI-friend in their communities (academic units, institutions, local groups); we will continue to provide mentoring support virtually during this phase of the program. Applications for this program will open July 2023, 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.

E505 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Updates on a New AIP Survey and Revised Two-Year College Physics Program Guidelines

Presenting Author: Sherry Savrda, AAPT-OPTYCs

Additional Author | Dwain Desbian, Estrella Mountain Community College

Among the initiatives undertaken by the Organization for Physics at Two-Year Colleges (OPTYCs) are a new AIP Survey of Two-Year College Physics Programs and the updating of AAPT's Guidelines for Two-Year College Physics Programs. The last AIP survey of two-year colleges took place in 2010, which means that the information about physics instruction in those institutions is outdated. Likewise, the Guidelines for Two-Year College Physics Programs were published in 2001. Many changes have taken place since then, including advances in pedagogy coming out of physics education research, and the advance of online instruction. This poster will review the rationale for these critical updates, and provide information on the work done to date.

E507 (7:00 to 8:00 PM Sunday) | Poster Presentation Traditional | Supporting Non-Traditional Students: How Chapters and Clubs Make an Impact

Presenting Author: Andrew Zeidell, American Institute of Physics/Sigma Pi Sigma

Non-traditional students can have a hard time finding community when entering higher education. Traveling the non-traditional path means that they may not have the time or resources to build the same types of social connections as traditional students. Chapters and clubs, like the Society of Physics students, and honors societies like Sigma Pi Sigma can serve as a launch pad for social connection for non-traditional students. These connections can be vital to success, as they form the nucleus of many study groups, and help facilitate a more cohesive student cohort, better performance, and a stronger and more enjoyable connection to physics. This poster will discuss ways that clubs and societies can create a culture of peer-mentorship, and other opportunities that they provide to strengthen the department.

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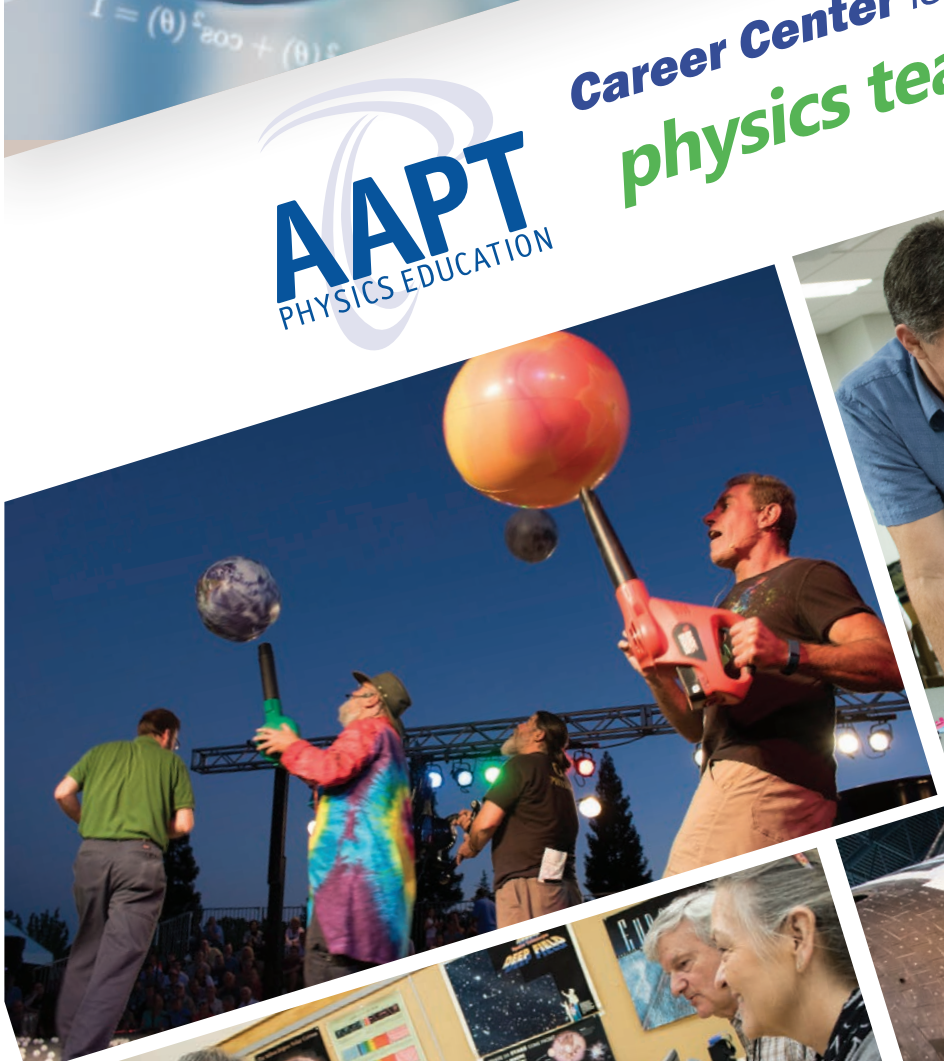

Session A01: Improving Student Learning of Quantum Mechanics I

Location: Ballroom A02 **Sponsor:** Committee on Physics in Undergraduate Education / **Co-Sponsor**: Committee on Research in Physics Education
Time: 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Alexandru Maries

A01-01 (9:00 to 9:24 AM Monday) | | Transitions and Representations in a Spins-First Quantum Mechanics Sequence

Presenting Author: Corinne Manogue, Oregon State University

Additional Author | Elizabeth A. Gire, Oregon State University

The Paradigms in Physics program at Oregon State University has spent 2 ½ decades exploring student engagement in a spins-first upper-division quantum mechanics sequence. We have found several topics where students need extra support in generalizing their understanding of content as they transition from simpler to more complicated quantum systems. In these cases, we have developed and adapted novel representations and activities to help scaffold students' understanding, including kinesthetic activities in which students use their bodies to represent geometric and physical relationships, video that animates graphs in three dimensions, skits that represent the measurement process, animations that allow students to explore parameter space, and other pedagogical representations. Come prepared to participate!
Supported in part by NSF grants: DUE 1836603 and DUE 1836604

A01-02 (9:24 to 9:48 AM Monday) | | Complementing Teaching Quantum Mechanics with Quantum Optics Labs

Presenting Author: Enrique Galvez, Colgate University

For about years now we have been offering an add-on lab component to an upper-level course on quantum mechanics at Colgate University. Because the course is elective, it has the benefit of enrolling students committed to the topic and lab (between 6 and 15). There are 6 experiments in the lab. The format has evolved over the years. Currently it focuses more on the physics of the experiments than on learning lab techniques. Covid prompted automating the apparatus, allowing students to do the experiment sequentially without degrading the setup. Students appreciate that in the labs they see an application of the quantum algebra (e.g. state projection, probabilities). I believe that the lab makes the students think more about what is happening to photons, leading them to confront the meaning and sgnificance of concepts such as superposition and entanglement.They still llearn to accept that quantum mechanics specifies the outcomes of measurements, although we do not promote a philosophical interpretation of the measurement process.
Funded by NSF grant PHY-2011937.

Session A02: Organizing for Successful Solar Eclipse Events

Location: Ballroom A03 **Sponsor:** Committee on Space Science and Astronomy
Time: 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Joe Heafner

A02-01 (9:00 to 9:24 AM Monday) | | Prepare Your Community to Get the Most from the 8-April-2024 Total Solar Eclipse

Presenting Author: Richard Gelderman, Western Kentucky University

A total solar eclipse is one of nature's truly remarkable events. Anyone outside the path of totality should do what is possible to get to a location where totality can be experienced. Everyone inside the path of totality should be prepared to safely enjoy the experience. Solar viewers are an affordable and arguably the most satisfying way to view the Sun during the phases of partial eclipse, with lower technology options available. Quality lesson plans involving the Sun and solar eclipses can be introduced now, well before the day of the eclipse. Because the experience of totality is such a powerful experience, consider recording video of the reactions of the people around you, instead of the sky.

A02-02 (9:24 to 9:48 AM Monday) | | Outreach with the Totality App and Beyond

Presenting Author: Jeff Bennett, Big Kid Science

The upcoming USA eclipses — annular on Oct. 14, 2023 and total on April 8, 2024 — will provide a pair of the best opportunities for science education outreach of our lifetimes. Toward that end, we have fully updated the free Totalityapp (details and app store links at https://www.bigkidscience.com/eclipse/) that allows users to interactively explore the eclipse paths and learn about eclipse science (and more); there is also a new book to accompany the app, called Totallity — An Eclispe Guide in Rhyme and Science. In this presentation, I will provide a brief overview of the app and discuss more generally how you can take advantage of the eclipse opportunity to engage in public outreach and to help ensure that K-12 schools (and colleges) will help their students to see and learn from these eclipses.

Session A03: Effective Practices for Developing Scientific Thinking, Reasoning and Decision-Making Abilities

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Krista Wood

A03-01 (9:00 to 9:24 AM Monday) | | Promoting Scientific Reasoning in the Introductory Physics Lab Course*

Presenting Author: Kathleen Koenig, University of Cincinnati

Additional Author | Krista E. Wood, University of Cincinnati

Additional Author | Lei Bao, The Ohio State University

The ability to effectively engage in evidence-based decision-making is an important educational outcome, yet the typical college course does not explicitly address the necessary underlying skills. 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 along with what we have learned about embedding question prompts and graphic organizers to promote skill development. The use of assessments, including the Inquiry into Student Thinking and Reasoning (iSTAR) assessment, will be discussed along with research outcomes for the impact of the curriculum on the three targeted skill areas. Access to the curriculum and scientific reasoning assessment will be provided to those interested.
*Partially supported by the NSF IUSE 1431908

A03-02 (9:24 to 9:36 AM) | Contributed Talk | Scientific Reasoning in a Two-Year College Introductory Physics Lab Course*

Presenting Author: Krista Wood, University of Cincinnati Blue Ash

Additional Author | Kathleen Koenig, University of Cincinnati

Additional Author | Lei Bao, The Ohio State University

Scientific reasoning (SR) skills are essential for effective scientific inquiry. At a two-year college, we implemented an inquiry-based introductory physics lab curriculum that targets SR skills: control of variables, data analytics, and causal decision-making. Using the Inquiry in Scientific Thinking, Analytics, and Reasoning (iSTAR), we investigated two-year college students' development of scientific reasoning skills with explicit focus on subgroups, including women and underrepresented minorities. We will share our results and discuss the lab curriculum implementation at a two-year college.
*Partially supported by the NSF IUSE 2110334

A03-03 (9:36 to 9:48 AM Monday) | Contributed Talk | Examination of Cause and Effect Using the Principles of the Rube-Goldberg Machine

Presenting Author: Brittney VornDick, Durham Technical Community College

For the Mechanics portion of the calculus-based physics course at Durham Technical Community College, pre-engineering students are tasked with conceiving a hypothetical Rube-Goldberg machine. The prime objective of the exercise is to analyze the interactions of objects moving through the machine. Students are expected to: (1) calculate time differentials; and (2) observe the effects on an object's interaction in the system as it moves through the different stages. Pedagogically, the project has been designed to embody Bloom's taxonomy. Over the course of the past three academic years, the project has also undergone key modifications, which will be demonstrated here.

A03-04 (9:48 to 10:00 AM Monday) | Contributed Talk | Engaging Students and the Public With a Planetarium Show about Dark Matter

Presenting Author: Michael Barnett, Lawrence Berkeley National Lab

Additional Author | Kaushik De, U. of Texas, Arlington

Additional Author | Reinhard Schwienhorst, Michigan State University

Three physicists made a highly successful planetarium show about Dark Matter called: Phantom of the Universe. It has been seen worldwide by over two million people. It has been in more than 730 planetariums in 74 countries and in 27 languages. Production was done by an international collaboration, which went to planetariums in several countries to view the work in progress. The show covers dark matter from the Big Bang to galaxies to a deep underground experiment to the Large Hadron Collider (LHC). It was quite interesting to work for a day with Academy Award-winning actor Tilda Swinton while recording the narration. Another two days was working on sound with an Academy Award-winning team at Skywalker Sound. Much of the show is in technical animation, Our target audiences were students and the public. For most planetariums, school visits account for about half their audiences. We found that many planetariums had a great interest in a dark matter show. They present our show for months at a time (unlike feature films). Planetariums have the perfect science-interested audience for us in the general public and K-12 students. We never imagined such success as we developed the show.

Session A04: PER: Assessment Ideas 2

Location: Ballroom A05 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Ryan Sayer

A04-01 (9:00 to 9:12 AM Monday) | Contributed Talk | Investigating the Quantum Mechanics Concept Assessment with Item Response Theory

Presenting Author: Jesse Kruse, University of Colorado Boulder

Additional Author | Bethany Wilcox, University of Colorado Boulder

To rigorously understand if our curricular and pedagogical choices are effective, we need tools to measure their effects. This is most commonly achieved with research-validated assessments which are tests of conceptual understanding that have undergone many rounds of revision until they meet standards for validity, reliability, and consistency. All of the research-validated assessments in physics have been analyzed using the lens of classical test theory (CTT), and a few introductory level assessments have been analyzed with the more rigorous item response theory (IRT). There is a notable lack of research on upper level quantum mechanics assessments using IRT. This talk outlines some preliminary results using IRT to analyze the Quantum Mechanics Concept Assessment (QMCA) with data from multiple universities gathered from 2018-2022. We present estimated item difficulties and person abilities for our data set, some of the limiting factors with our analysis, and how we hope to extend this work to future projects.

A04-02 (9:12 to 9:24 AM Monday) | Contributed Talk | A Characterization of Existing Quantum Mechanics Assessments

Presenting Author: Molly Griston, University of Colorado Boulder

Additional Author | Jesse Kruse, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

With the rapid growth of quantum information science and technology, it is essential that we are able to build educational programs that cultivate a quantum-literate workforce. An important part of this process is assessing student learning in undergraduate quantum courses. To best support a variety of educational goals and encourage wide adoption, we aim to develop a flexible coverage assessment that both draws from existing static quantum mechanics assessments and includes new items to address quantum mechanics topics that are not currently covered in existing assessments. As an initial step toward developing such an assessment, we present a characterization of the existing quantum mechanics assessments, including a summary of the scope of current questions as well as an identification of missing topics.

A04-03 (9:24 to 9:36 AM) | Contributed Talk | Item Response Theory Analysis of the Energy and Momentum Conceptual Survey in Calculus-Based Physics for Life Sciences

Presenting Author: Xian Wu, University of Connecticut

Additional Author | Hongmin Shao, University of Connecticut

Additional Author | Erin M Scanlon, University of Connecticut

Additional Author | Matthew W Guthrie, University of Connecticut

The Force Concept Inventory (FCI) has been widely studied in physics education research, yet little attention has been given to other conceptual instruments. Our study focuses on the Energy and Momentum Conceptual Survey (EMCS), which has been administered in our calculus-based introductory physics for life sciences (IPLS) courses since 2021. Using Item Response Theory (IRT), we examine the structure of the EMCS data, including item difficulty, discrimination, and guessing effects. Our presentation will provide preliminary results that enhance our understanding of life sciences students' conceptual understanding of energy and momentum. These findings will contribute to the development of effective instructional strategies for physics education that are relevant to the topics covered in our IPLS courses.

A04-04 (9:36 to 9:48 AM Monday) | Contributed Talk | Context Dependence of Introductory and Advanced Student Reasoning in Introductory Thermodynamics

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | David Meltzer, Arizona State University

Additional Author | Chandralekha Singh, University of Pittsburgh

We use a validated multiple-choice survey instrument focusing on thermodynamic processes and the first and second laws of thermodynamics to investigate context dependence of introductory and advanced student reasoning in introductory thermodynamics. The survey includes items that incorporate many contexts involving variables such as internal energy, work done by a system, and heat transfer; here, however, we focus exclusively on entropy. We present analysis of data in multiple contexts reflecting students' ideas about the change in entropy of a gas, both in spontaneous/irreversible processes and in cyclic processes. Consistent with prior studies, we find the idea that entropy is constant for an isolated system to be widely prevalent among introductory students, while advanced students—by contrast—had great difficulty with situations in which entropy of the system does not increase. Thus, our findings using a validated survey confirm the findings of prior research in multiple contexts.

Session A05: PER: Student Experiences & DEI

Location: Ballroom A06 **Sponsor:** Committee on Research in Physics Education **Time:** 9–10 a.m.
Date: Monday, July 17, 2023 **Presider:** Maajida Murdock

A05-01 (9:00 to 9:12 AM Monday) | Contributed Talk | Integrating Qualitative and Quantitative Approaches to Investigate Self-Efficacy

Presenting Author: Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Reseachers have shown self-efficacy - or one's confidence in their abilities to complete a task -- predicts persistence and achievement in science. Within academia, students may encounter threats or supports to their self-efficacy that may eventually influence their persistence in the sciences. To examine these threatening or supportive moments in a student's experience, we employed a mixed methods approach. Our approach couples the Experience Sampling Method (ESM), a technique that uses surveys to probe a numeric measurement of a student's domain-specific self-efficacy, with individualized daily journal reflections. In our design, the ESM survey responses informed the writing of the individualized daily journal prompts, which, in turn, link quantitative and qualitative data sources. In this talk, we will discuss how our point of integration changed over two iterations of data collection; specifically, how the use of the open-ended survey questions influenced how we further probed into students' self-efficacy.

A05-02 (9:12 to 9:24 AM Monday) | Contributed Talk | Research on LGBTQ+ Student Experiences in California

Presenting Author: Jacob Garner, San José State University

Co-presenting Author | Brianne Gutmann, San José State University

Co-presenting Author | Gina Quan, San José State University

As the physics education community continues to push for more equitable classroom and academic practices, there is a need for more explicit attention to the experiences of LGBTQ+ physics students. This ongoing study strives to better understand LGBTQ+ students' experiences in college via interviews with LGBTQ+ undergraduate and graduate students across multiple higher education institutions in California. Interviews focus on students' perceptions of physics as a major for LGBTQ+ people, their support systems, and ways that their identities (LGBTQ+ and others) have affected their college careers. Preliminary results of emerging themes from interviews and potential takeaways will be shared.

A05-03 (9:24 to 9:36 AM Monday) | Contributed Talk | The Undergraduate Lab at Berkeley (ULAB): Increasing Accessibility in Physics and Astronomy Research

Presenting Author: Saahit Mogan, University of California, Berkeley

Additional Author | Ravjit Kaur, University of California, Berkeley

Additional Author | Anmol Desai, University of California, Berkeley

At large public institutions with a high undergraduate to faculty ratio, traditionally underrepresented students in academia face unique obstacles in accessing research opportunities. As research is a vital part of an undergraduate physics education, creating tools to counter this disparity is essential. We present The Undergraduate Lab at Berkeley (ULAB), an undergraduate-led course designed to introduce research to underrepresented and marginalized students at UC Berkeley. ULAB takes a two-pronged approach: students learn research skills via lectures and gain hands-on experience with an undergraduate mentor. In a small group of their peers, ULAB mentees propose and conduct a year-long project that simulates formal undergraduate research. We evaluate the efficacy of the program through a survey that adresses students' sense of belonging and confidence in research skills within ULAB and the greater physics community. Building on a pilot survey conducted during the 2021-22 academic year, we take a more qualitative approach by emphasizing student testimonials from current and past years. In conjunction with the Berkeley Undergraduate Research Evaluation Tools (BURET) group, we measure the success of the program and investigate how ULAB may further support diversity, equity, and inclusion in physics and astronomy.

A05-04 (9:36 to 9:48 AM Monday) | Contributed Talk | Using Community Cultural Wealth to Understand Experiences in Physics Bridge Programs

Presenting Author: Jenna Tempkin, Lafayette College

Co-presenting Author | Geraldine L Cochran, Rutgers University

Additional Author | Téa Boone, St. Mary's University

Many conceptual and theoretical frameworks in education research tend to value social and cultural capital from the most privileged groups and focus on what people from marginalized groups are "lacking." This kind of research often employs a deficit model of understanding the experiences of people marginalized in education. To fully understand the academic experiences of students from marginalized groups it is important to focus on the capital these groups use to overcome challenges. The Community Cultural Wealth (CCW) framework values resources Communities of Color have to help them through various systems such as education. The goal of this project is to understand which forms of CCW students in physics bridge programs utilize during their academic journey. Specifically, we wanted to understand which forms of CCW students utilize when deciding to pursue graduate education in physics and when they face challenges while in graduate school. To do so, we conducted semi-structured interviews with participants in physics bridge programs from 4 different institutions, and used qualitative coding to identify examples of each of the 6 types of CCW.

This work is supported in part by the Rutgers Department of Physics & Astronomy, the Inclusive Graduate Education Network, and the Rutgers Physics & Astronomy REU. This material is based upon work supported by the National Science Foundation under Award No. (2050950). Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

A05-05 (9:48 to 10:00 AM Monday) | Contributed Talk | Framework for Unpacking Students' Experiences in Introductory Physics Part I: Four Functions of Course Features

Presenting Author: Ellen Ouellette, University of Illinois Urbana-Champaign

Additional Author | Sarat Lewsirirat, University of Illinois Urbana-Champaign

Additional Author | Ryan Biju Sebastian, University of Illinois Urbana-Champaign

Additional Author | Christina Krist, University of Illinois Urbana-Champaign

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

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

Course structures – which encompass curriculum materials and activities, how this curriculum is enacted, how students are assessed, and other course logistics and policies – impact students' learning, beliefs about themselves as learners, and motivation. As part of an effort to redesign course structures to increase student success in introductory physics at the University of Illinois, we conducted 30 1-hour, semi-structured interviews with introductory physics students to investigate their experiences with our local course structures. These students described their perceptions of course features in terms of four major functions: defining learning tasks, supporting collaboration, providing opportunities for feedback, and determining grades. How students experienced these functions depends both on the design of the component's particular features and on the students' personal orientations. For illustrative case comparisons, we will present the different ways students attend to and interpret features of weekly small-group problem solving sections in physics and chemistry. A future goal of this work is to support integrated (rather than piecemeal) course design efforts by understanding how multiple course features and components come together to impact students.

Session A06: Teaching About How Science is Done to Impact Careers and Professionalism

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Shahida Dar

A06-01 (9:00 to 9:12 AM Monday) | Contributed Talk | Educational Methods for First and Second Year Undergraduate Physics Students to Prepare for a Future in Physics

Presenting Author: Mara Casebeer, Harvard University

Additional Author | Alex Frano, University of California, San Diego

There are many barriers keeping undergraduate physics students from pursuing research both in their undergraduate careers and beyond. One potential barrier is understanding the process of scientific research–many students perceive physics research as solving textbook problems. This unnecessarily alienates many students from underserved backgrounds. We introduced first and second year physics-major physics students to research-oriented projects and coding guides to increase awareness, access, and preparation for research careers. The project involved reading a scientific paper from a professor at this university and reaching out to the authors of that paper. We analyze the pre-post gains in confidence in research and coding of science students after introducing these methodological changes (n=40-45). Our results show that introducing students to a research-oriented project increased their confidence in their ability to understand and conduct research. Similarly, introducing students to python-based physics problems in the context of physics classes resulted in more confidence in their coding skills. Both of these methodologies can be adapted and implemented in other courses. More assessment of how these methodological changes can impact scientific identity, self-efficacy, and community values is being done.

A06-02 (9:12 to 9:24 PM Monday) | Contributed Talk | Reshaping Students' Professionalism through a Unique Adaptation of the Traditional One-Dimensional Elastic Collision Experiment

Presenting Author: John Walkup, Oklahoma State University - Stillwater, OK

Co-presenting Author | Roger Key, California State University, Fresno

The goal of this lab activity is to shake students' view of their own integrity and generate discussion on what it means to be a career professional. The work associated with academic degree requirements contrasts sharply with the soft skills needed to conduct oneself as a practicing scientist or engineer. Apparently, college STEM departments pay more attention to developing academic content knowledge (e.g., theory, mathematics, experimental procedures) than promoting workplace professionalism. Because worldview plays such an important role in shaping workplace attitudes, the building of soft skills in prospective scientists and engineers surfaces naturally as a ripe target for a pedagogical scheme called transformative learning. Here, we describe an activity suitable for most introductory physics labs that employs the principles of transformative learning to move students toward developing the professional attitudes demanded of future scientists and engineers. By conducting the traditional one-dimensional elastic collision experiment, students are led unawares to a perplexing situation that betrays improper conduct, dishonest claims of results, inadequate troubleshooting, and professional ethics violations.

A06-03 (9:24 to 9:36 AM Monday) | Contributed Talk | Social Aspects of Computation Used by Researchers in Physics and Other STEM Disciplines

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

Additional Author | Tony Wong, Rochester Institute of Technology

Additional Author | Benjamin M Zwickl, Rochester Institute of Technology

Additional Author | Kayleigh Patterson, Rochester Institute of Technology

Additional Author | Mikayla MacIntyre, Rochester Institute of Technology

Computation is critical in contemporary physics research and across STEM research more broadly. However, the elements of computational literacy most prioritized in classroom practice often leave the social aspects of computation underemphasized. Moreover, the unique skills associated with effectively collaborating and communicating in the context of computationally intensive research are not well described. To better understand these social aspects of computation in research environments, we designed an interview protocol based on a literacy framework for computational understanding composed of social, material and cognitive components. Interviews with 16 STEM faculty members, including 5 physics and astronomy researchers, yielded nuanced insight into how scientists communicate with and about computation in their daily work. This talk will identify common tools and practices that help researchers across disciplines program cooperatively. We highlight several ways that researchers share code and generate detailed documentation to promote organization across large collaborations. We also explore how researchers consider who will read and use their code, adapting their practices accordingly. We hope that identifying these features will inspire new strategies and more explicit attention for incorporating social features of computation into physics classrooms.

A06-04 (9:36 to 9:48 AM Monday) | Contributed Talk | Using Physics Demo Development and Outreach as a CURE

Presenting Author: Michael Cone, Rice University

Additional Author | Julie S Hoeink, Rice University

Additional Author | Robert P Beaird, Rice University

In recent years there has been considerable interest surrounding the integration of Course-Based Undergraduate Research Experiences (CUREs) into the standard undergraduate physics curriculum. These courses can provide the student with valuable skills and experience, and can also instill a sense of ownership that is typically not there in traditional courses. While the existing faculty-headed research programs can certainly be used as the foundation for a CURE, we feel that the design and development of high-quality physics demos can provide another alternative. With this in mind, we have created a course wherein the students select a demo that they find interesting, and over the course of the semester they work to develop the demo. Additionally, we have the students create a poster for their project (at a level suitable for outreach activities), and give a formal presentation of their work to the department at the end of the semester. These projects involve many of the same skills and challenges that go along with actual research, but at a level that is more accessible for younger students. A CURE like this can also be particulary attractive for non-research faculty, or institutions without a large research program.

Session A07: Decolonizing Physics in the Curriculum

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Clausell Mathis

A07-01 (9:00 to 9:24 AM Monday) | | Decolonizing Physics Working Group: Facing and Reshaping the Dominant Western Narrative

Presenting Author: Elissa Levy, Hunter College High School

Inspired by the Underrepresentation Curriculum's February 2021 Unconference, a nationwide group of about 10 physics teachers created an offshoot initiative to "decolonize" high school physics curricula. The idea was this: responsive teaching strategies and conversations about underrepresentation are imperative but still take place within the structures of traditional classrooms. We call ourselves the Decolonizing Physics Group, although a fully decolonized field of physics is an aspiration and not necessarily a realistic destination. Our goals are (a) to explore how "physics" came to be defined the way it is, (b) to find alternative definitions and curricula, (c) to learn about physics' global history (which we were not taught as students), (d) to develop frameworks for decentering white, male Europe from the content we teach, and (e) to actually teach and revise lessons that we develop together. Physics is better (better innovations, better service to humanity) when our courses are consciously built on a global narrative. This talk will share some of the structures and struggles of doing this fraught work in a national collaboration with no single leader, vision, or framework guiding us on our journey. The work is hard and it's messy, and it's utterly necessary.

A07-02 (9:24 to 9:48 AM Monday) | | Building Physics Identities: Developing Culturally Responsive Physics Pedagogies in Various Classroom Contexts

Presenting Author: Praisy Poluan

Co-presenting Author | Jay Kurima

Co-presenting Author | Jamie Avalos

Building physics identities is essential for active student participation in physics courses and continued success in the field. Using Culturally Responsive Physics Pedagogy (CRP2), such as inclusive classroom environments and social-emotional learning strategies, we explore how three diverse physics classrooms were augmented to help marginalized populations of students strengthen their physics identities. Join us as we delve into the exciting world of CRP2. Gain insights from the perspectives of dedicated high school physics teachers who will share their impetus for undertaking this project, their unique definition of CRP2, their experiences implementing it over the course of a year, the valuable lessons they learned along the way, and their plans for future steps. This transformative initiative was developed within a community of practice, comprised of other physics educators with a wide range of international interests and expertise.

A07-03 (9:48 to 10:00 AM Monday) | Contributed Talk | Locating and Abolishing Anti-Blackness in Physics Curricula

Presenting Author: Deepak Iyer, Bucknell University

Drawing on frameworks of abolition and critical race theory in education, we critically analyze physics curricula for baked in anti-Blackness. We use several lines of critical inquiry to trace the histories and modern day versions of anti-Black practices in physics education, and how that leads to the vast disparities that we observe in outcomes. We will then look ahead to an alternative vision of physics education that actively confronts this history while shedding the baggage, with a view towards an undergraduate physics curriculum that truly embraces a liberatory pedagogy and a liberatory practice of physics.

Session A08: Calling TYCs! About OPTYCs: The Organization for Physics at Two-Year Colleges

Location: Ballroom A09 **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 9–10 a.m.
Date: Monday, July 17, 2023 **Presider:** Glenda Denicolo

A08-01 (9:00 to 10:00 AM Monday) | | Overview of OPTYCs: Who We Are and What We Offer

Presenting Author: Dwain Desbien, Estrella Mountain Community College

The Organization for Physics at Two Year Colleges (OPTYCs) provides professional development and collaborative activies for TYC physics faculty. This talk will provide an overview of the opportunities for TYC physics faculty to get involved and highlight our activies in PER and continuing professional development. This talk will also include highlights of our first year and provide a look into the next year! Come find out how you can get involved.
This project is supported by AAPT and funded by NSF-DUE-2212807

A08-03 (9:00 to 10:00 AM Monday) | | DEI Capacity-Building Immersive Discussion Program Offered by OPTYCs

Presenting Author: Kris Lui, AAPT - OPTYCs

The Organization for Physics at Two-Year Colleges (OPTYCs) will offer a cohort program for faculty who are interested in expanding their capacity for diversity, equity, and inclusion efforts. The aim of this program, beginning January 2024, is to create a learning community among TYC physics-related teaching instructors who are committed to self-exploration, self-improvement, and working in challenging spaces to promote an equitable environment for all students in their classes. This presentation will outline the goals, structure, and timeline for this DEI Program. (OPTYCs is supported by NSF-DUE-2212807.)

Session A09: Teaching IPLS

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Juan Burciaga

A09 (9:00 AM to 10:00 AM Monday) | | From IPLS to Upper Division Courses – Physics of Medical Imaging and Radiation Oncology

Presenting Author: Nancy Donaldson, Rockhurst University

Over the past decade, the physics department at our small, liberal arts university has made a concerted effort towards transformation and growth through the design of new active-learning physics courses past the IPLS level that are relevant to our students' career interests in medicine. Our Physics of Medicine (POM) Major, designed for pre-medical/pre-health students, focuses on deepening students' physics understanding and critical thinking/reasoning skills through the lens of medicine. One of our POM Major courses, Physics of Medical Imaging, concentrates on physics concepts required for an understanding of contemporary medical diagnostic and treatment procedures. Curriculum investigates the physics principles underlying modern medical diagnostic and therapeutic technology: Electromagnetic Energy, Interaction of radiation with matter, Diagnostic Radiation (X-Ray, CT), Nuclear Medicine (Gamma Camera, SPECT, PET), MRI, hybrid instrumentation and External beam/Radioactive Decay Radiation Treatment. Students extend their physics understanding by investigating how these diagnostic and therapeutic instruments work as well as the numerous physics and patient factors that contribute to the choice of technology for diagnosis and treatment. The course culminates with a field trip to visit Medical Physicists at the Radiation Oncology Department of a local hospital for a tour of CT Treatment Mapping, Dosimetry, the LINAC, and the Gamma Knife.

A09-02 (9:00 to 10:00 AM) | | Medical Physics: Using Science to Improve Medical Care

Presenting Author: Sonja Dieterich, University of California - Davis - Davis, CA

Medical Physics and dosimetry is an exciting career for scientists who want to combine advanced technology with applications in the life sciences. It offers a career using science to directly impact patient care. Many topics from the toolbox of a medical physicist can serve as practical examples on how concepts taught in high school or undergraduate physics are applied to diagnosing and treating patients. Medical physics encompasses a wide range of curriculum topics across biology, physics, biomedical engineering and computational sciences. Many medical physicists work in therapeutic medical physics, which uses linear accelerators producing photons, electrons or particles as well as sealed and unsealed brachytherapy sources for the treatment of cancer and benign diseases. Imaging physics focuses on advancing technology to diagnose health conditions and study physiological processes. Theranostics is a combination of both fields, were radioactive materials are used for both imaging and simultaneous treatment. Health physics addresses radiation protection for radiation workers and the general public. These medical physics specialties open several career paths for medical physicists: we are employed in academic and private clinics either as employees or consultants. There are careers in healthcare, industry, government, and one of us is even an astronaut for NASA.

A09-03 (9:00 to 10:00 AM) | | Medical Physics: Pathways for STEM students

Presenting Author: Scott Hoopingarner, UC Davis

Medical Physics is an exciting, ever growing and changing career path for STEM students to pursue. It is subdivided into three primary subsets: radiation therapy, imaging, and radiation protection. There are academic pursuits, clinical, consulting, industry, or combinations to be explored. The basics taught in undergraduate physics programs (such as classical mechanics, relativity, electromagnetism, atomic/nuclear theory, etc.) are expanded upon in graduate programs (either MS or PhD) to apply to cutting edge technology such as medical linear accelerators, MRI, theranostics, and more. Additionally, medical physics is a multi-disciplinary field that is directly interwoven with radiation biology and biomedical engineering. This aspect makes medical physics a particularly attractive career for those with interests in collaboration with many specialists. Paths to medical physics vary greatly and enrich our field by bringing in unique and novel approaches to problem solving. People with backgrounds in general/applied physics, nuclear engineering, biology, mathematics, and more are all able to continue into graduate or certificate programs for medical physics and then onto residency and board certification. An overview from a physics undergraduate to a master's in medical physics, to a therapy physics residency will be covered and how the various levels of education impact the career journey.

Session A10: Accessible Lab Equipment

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Max Nam

A10-01 (9:00 to 9:12 AM Monday) | Contributed Talk | Simple Acoustic Experiments at Home

Presenting Author: Martin Monteiro, Universidad ORT Uruguay

Additional Author | Arturo C. Marti, Instituto de Física, Facultad de Ciencias, UdelaR

Additional Author | Cecilia Stari, Instituto de Física, Facultad de Ingeniería, UdelaR

In this work we present some examples of acoustics laboratories that can be carried out with low-cost equipment, which during the pandemic were essential to maintain activities in our experimental physics courses. In particular, we will show a simple inexpensive experiment on acoustic resonance that students can carry out at home, using a smartphone and the extendable tube of a vacuum cleaner. Producing sound by gently hitting one end of the tube with the palm of an open hand, the resonant frequencies for different lengths of the telescopic tube can be measured with a smartphone. This is possible thanks to the great camputational capacity of smartphones, which allows them to perform the FastFourier Transform in real time, this being one of the many factors that convert these pocket computers into portable laboratories, available in the most diverse circumstance, whether during confinement or a field activity, among many others.
References:
M.Monteiro, C.Stari, and A.C.Martí, "A home-lab experiment: resonance and sound speed using telescopic vacuum cleaner pipes," Physics Education 58, 013003 (2023). doi.org/10.1088/1361-6552/ac9ae1
M.Monteiro, A.C.Martí, "Resource Letter MDS-1: Mobile devices and sensors for physics teaching," American Journal of Physics 90, 328 (2022). doi.org/10.1119/5.0073317

A10-02 (9:12 to 9:24 AM Monday) | Contributed Talk | Shelf Bought: Digital Physics Sensors

Presenting Author: Robert Krakehl, Manhasset Secondary School and Stony Brook University

The idea of utilizing open source technologies to create digital sensors in the physics classroom is not a new one. There are several tutorials online for how to build, code and use motion sesnsors and photogates using arduinos or mother microcontrollers. As more classrooms implement NGSS and AP Physics course offerings increase, the need for real time data acquisition is growing. While many experiments in physics can be accomplished with a meter stick and a stopwatch, real time data collection allows for more accessible modeling, argumentation, refininging experimental techniques and data analysis in the classroom. Open source sensors have diminished the cost barrier to digital sensors, but still require the users to build and trouble shoot the equipment. This talk will present work done by myself and the PoLS-T network on implementing budget friendly and easy to use digital sesnors in the classroom. I will discuss open source off the shelf options that are plug and play, ideal for the physics classroom - and even other science classrooms. Discussion regarding costs, ease of use, and implementation in the classroom will be presented.

A10-03 (9:24 to 9:36 AM Monday) | Contributed Talk | Internet of Things (IoT) & Artificial Intelligence (AI) relevance to Sustainable Development

Presenting Author: Dharmbir Singh

Internet of Things (IoT) & Artificial Intelligence (AI) technologies are contributing a lot in Sustainable Development by increasing interconnectivity and smart automation. Internet of Things (IoT) & Artificial Intelligence (AI) technologies are increasing Interconnection ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of things. Futher, these technolgies are helping in automation, improving communication and self-monitoring, and the use of smart machines that can analyze and diagnose issues even without the need for human intervention. These Technologies also help humans in decision-making and problem-solving, and the ability to help humans with difficult or unsafe tasks. IoT devices can be used to enable remote health monitoring and emergency notification systems. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers, Fitbit electronic wristbands, or advanced hearing aids etc. This paper persents such several aspects of Internet of Things (IoT) & Artificial Intelligence (AI) technologies which are contributing a lot in Sustainable Development.

Session A11: Climate & Energy in the Classroom

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Frank Lock

A11-01 (9:00 to 9:12 AM Monday) | Contributed Talk | Climate and Estimation in HS Physics

Presenting Author: Valerie Risk, Albany High School, Albany CA

I will share how I incorporated Climate and Estimation topics based on NGSS into my high school Physics curriculum. I teach a college-prep course to 11th and 12th graders. Estimation is a great tool for understanding order of magnitude energy consumption, both personally and globally. We used estimation to examine the feasibility of various sustainable power generation options. Students researched solutions globally, nationally, and locally and engaged with leaders in their community to advocate for change.

A11-02 (9:12 to 9:24 AM Monday) | Contributed Talk | A Free, On-line Text for Middle School Earth & Space Science -- Climate Change Focus

Presenting Author: Jeff Bennett, Big Kid Science

In this presentation I will introduce you to a free, online resource for middle school Earth & Space Science, focusing on the chapters devoted to climate science and climate change. You can explore the project for yourself at grade8science.com. The project meets all NGSS standards for MS-ESS, and can be used without the need for any other resources, as it includes discussion, teacher notes, assessments, and much more. Much of the curriculum can also be used at the high school level.

A11-03 (9:24 to 9:36 AM Monday) | Contributed Talk | Energy in its Material and Social Context: Power Plants

Presenting Author: Rachel Scherr, University Of Washington Bothell

Additional Author | Lane Seeley, Seattle Pacific University

Additional Author | Kara E. Gray, Seattle Pacific University

One way for science teaching to have significance beyond the classroom is for science education to be in the service of community organizing and ethical decision making. Power plants have tremendous social significance both locally and globally. In what follows, we will consider the energy dynamics of two electrical power production facilities: (1) the largest coal-fired electrical power production facility in the US, and (2) one of the facilities that provides significant electrical power to the authors. Rather than analyzing power plants apart from their material and social context, we suggest an analysis that includes the relationships between the power plant and the surrounding human, plant, and animal communities, as well as lands, waters, and air. Our intent is to model an approach to energy learning that begins to prepare students to engage in ethical decision making about energy resources.

A11-04 (9:36 to 9:48 AM Monday) | Contributed Talk | Climate Generations: A Climate Game Spanning Borders and Legacies

Presenting Author: Elana Resnick, ASRC Federal/ NASA Goddard Space Flight Center

Additional Author | Alex Ruane, Goddard Institute for Space Studies

Additional Author | Natalie Kozlowski, Columbia University

Additional Author | Sebastian Peralta, University of Central Florida

Additional Author | Gabriel Rodriguez, Florida International University

Additional Author | Heldanna Solomon, University of Central Florida

In this talk, we present "Climate Generations"; a collaborative video game adventure developed at NASA for middle and high school students (12-18 years old). Built around physics principles, gameplay draws from leading NASA climate and impact models as well as key messages and responses outlined in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report. Game design is supported by curricular resources that can be adapted by educators to meet the needs of their students. Similar to a Model United Nations conference, the entire classroom plays a single game. Players are assigned to represent a country at different points throughout history; this generational gap in policy decisions highlights the long-term consequences of early action or inaction. Through play and supporting curricula, students are encouraged to consider the diversity of perspectives in climate action across regions, interests, and generations that might differ from their own. They will need to work together to overcome many of the same snags that have held up climate action in the real world.

A11-05 (9:48 to 10:00 AM Monday) | Contributed Talk | Eunice Newton Foote: Climate Science Pioneer

Presenting Author: Kathryn McGill, University of Florida Department of Physics

Additional Author | John Perlin, UC Santa Barbara Department of Physics

Additional Author | Ann C. Wilkie, University of Florida Institute of Food and Agricultural Sciences

Additional Author | Kathleen W. Pagan, Climate Reality Project (Gainesville, FL Chapter)

Eunice Newton Foote was the first scientist to demonstrate that carbon dioxide is a greenhouse gas, and also the first scientist to suggest that an atmosphere containing high levels of carbon dioxide would lead to a warmer earth. She wrote about the experiments she performed in studying the warming of a variety of gases in her 1857 publication in the American Journal of Science and Arts, finding that the warming was most pronounced in the cases of moist air and carbon dioxide. In this talk we will discuss Foote's contributions to climate science and the reactions of her contemporaries to her findings. We will also discuss the connection between Foote's scientific achievements and her work in women's rights.

Session A12: Panel: Promoting EDI in Physics through Social Media

Location: Meeting Room 03 **Sponsor:** Committee on Science Education for the Public
Time: 9–10 a.m. **Date:** Monday, July 17, 2023 **Presider:** Sarah Johnson

Many physics instructors have discovered the benefits of engaging with each other and the general public via social media. Panelists who have been active promoting EDI (Equity, Diversity and Inclusion) in physics spaces via social media will discuss their experiences doing so. They will share how they got started and the impact of their social media activities on themselves and the physics community.

Session A13: TYC: Discourse in your Classroom

Location: Meeting Room 09 **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 9:30–10:30 a.m.
Date: Monday, July 17, 2023 **Presider:** Dwain Desbien

This workshop will focus on what we as instructors can do to improve student discourse in our classes. You will experience the techniques as you learn and hopefully will come away with a few new tools to use in your own classroom. This workshop will be interactive and engage you in the process of developing discourse.

Session B01: What Knowledge Counts as Science?

Location: Ballroom A02 **Sponsor:** Committee on History & Philosophy of Physics **Time:** 10–11 a.m.
Date: Monday, July 17, 2023 **Presider:** Vanessa Dela Paz Maca

The question of how to distinguish different types of knowledge goes back millenia. What approaches have you taken to distinguish science from other types of knowledge? How do you discuss the relationship between science and those other forms of knowledge?

Session B02: Organizing for Successful Solar Eclipse Events

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Joe Heafner

B02-01 (10:00 to 10:12 AM Monday) | Contributed Talk | 99.887% is Good Enough, Right?

Presenting Author: David McCallister, Windermere Preparatory School

Educators across the country addressed a peak in public interest preparing for the total solar eclipse of 2017. Space science outreach staff at a large public university completed early stages of planning for a large outreach viewing event off-campus, since the campus was just outside totality. In preparation for the eclipses coming in 2023 and 2024, this talk will outline the successes and challenges in public outreach ahead of the 2017 eclipse, as well as information from the early stages of planning before the eventual failure to convince the powers-that-be to organize an off-campus event inside totality.

B02-02 (10:12 to 10:24 AM Monday) | Contributed Talk | Reaching Rural: Lessons Learned from the 2017 Total Solar Eclipse

Presenting Author: Matthew Cass

As a prime location along the path of totality in 2017, the rural region of western North Carolina enjoyed a once-in-a-lifetime experience. The Smoky Mountains STEM Collaborative, a NASA Science Activation partner, was responsible for organizing and supporting events that occured at locations ranging from town centers, K - 12 schools, the community college, informal science centers, and the Great Smoky Mountains National Park. Each location provided unique opportunites and challenges requiring special considerations. Learn from my experience on how to provide a safe and educational eclipse event for rural audiences.

B02-03 (10:24 to 10:36 AM Monday) | Contributed Talk | Activities for Appreciating and Observing a Total Eclipse of the Sun

Presenting Author: Dan Burns, PTSOS

I have been fortunate to witness 3 total eclipses, 2 annular eclipses, and many partial eclipses of the Sun with my family, friends, and students. In 2017 I helped Lowell Observatory with their eclipse event at Madras High School. I will share what I have done to help others appreciate and observe solar eclipses. This includes demonstrations, observational techniques, projects, and activities.

Session B03: Effective Practices for Developing Scientific Thinking, Reasoning, and Decision-Making Abilities in Intro

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Doug Petkie

B03-01 (10:00 to 10:12 AM Monday) | Contributed Talk | Assessment of Student Knowledge Integration in Learning Work and Mechanical Energy

Presenting Author: Jia Liu, East China Nomal University

Additional Author | Dazhen Tong, East China Nomal University

Work and mechanical energy is a fundamental topic in introductory physics. Studies in existing literature have shown that students have difficulties in understanding work and mechanical energy, particularly the topic of work-energy theorem. To study students' knowledge integration in learning work and mechanical energy, a conceptual framework model of work and mechanical energy was developed and applied to guide the design of an assessment for measuring students' level of knowledge integration. Using the assessment, qualitative and quantitative data were collected in two high schools in an eastern Chinese city. The results reveal that the conceptual framework model can effectively represent the students' knowledge structures at different levels of knowledge integration. In addition, the assessment is shown effective in identifying unique features of knowledge integration, including context dependence and fragmentation of knowledge components, memorization-based problem-solving strategies, and lack of meaningful connections between work and change in kinetic energy. The conceptual framework of work and mechanical energy and assessment results can provide useful information to facilitate instructional designs to promote knowledge integration.

B03-02 (10:12 to 10:24 AM Monday) | Contributed Talk | An Intervention for Multiple Choice to Enhance Problem Solving Skills and Mitigate Sex Differences

Presenting Author: Marianna Ruggerio, Auburn High School

Multiple choice items in physics tend to require multiple layers of understanding by the student to demonstrate proficiency on a single item. Students frequently share frustration that the answer is clear after the exam, but they struggle to notice important details during the exam. Previous research has indicated a relationship between a student's cognitive reflection test score and their physics exam performance. This is particularly notable on the AP Physics 1 exam. Nationally, male students earn a score of 5 at a rate of nearly triple their female counterparts. This talk will discuss an intervention implemented before the exam and its impact on student testing performance during the course.

B03-03 (10:24 to 10:36 AM Monday) | Contributed Talk | Emergent Explicit Regulation in Collaborative College Science Classrooms: A Case Study

Presenting Author: Andrew Burns, Drury University - Springfield, MO

Co-presenting Author | Ying Cao, Drury University - Springfield, MO

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. Productive collaboration requires students to monitor and regulate themselves, especially when challenges arise. Previously, we 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 from college freshmen engaged in various types of activities (e.g., reading and discussing scientific articles, designing and conducting experiments, and model building), we identified instances of EER and categorized them based on their target areas, including cognition, behavior, motivation, emotion, and social interaction. Notably, 35% of the students in our data set were communicating with American Sign Language (ASL) or a computer keyboard. In our previous work, we analyzed small groups consisting of all speaking students and identified EER instances in each target area. In this study, we expand our analysis to include a group that has one student using ASL to communicate. We attempt to lay out a timeline of the EER instances within the group during a class period, with the hope of better understanding any possible evolutionary patterns of EER during the activity.

B03-04 (10:36 to 10:48 AM Monday) | Contributed Talk | Visual Approaches for Students to Better Analysis Complex Electric Circuits

Presenting Author: YILI LIAO, Yili Physics Academy

I want to share a new teaching method for teachers who are teaching their students on complex electric circuit analysis. In my 10 more years teaching experience, I found that although students knew about Kirchhoff's laws, they still lack intuition to figure out the potential in each part of the circuits. Instead, they always try to find out the current first. I invented a coloring method to help them build a vivid sense of potential distribution in the circuits. By this way students can easily find out the potential difference on each equipment and hence find out current direction in the circuits. I will share examples in different type of circuits including circuits affected by magnetic induction. I will also introduce the pro and con of this method and willing to listen any suggestions. This method has been put into practice in my AP physics, Physics Bowl, and other physics competition class for more than 3 years. The feedback from my students is pretty good. So I want to share this method with all my colleagues in this summer meeting and glad to receive their constructive suggestions.

Session B04: PER: Assessment Ideas 2

Location: Ballroom A05 **Sponsor:** Committee on Research in Physics Education **Time:** 10–11 a.m.
Date: Monday, July 17, 2023 **Presider:** Ryan Sayer

B04-01 (10:00 to 10:12 AM Monday) | Contributed Talk | Examining the Factor Structure of the Colorado Learning Attitudes about Science Survey

Presenting Author: Dona Hewagallage, West Virginia University

Additional Author | John C Stewart, West Virginia University

Multiple studies have suggested that the factor structure originally published for the Colorado Learning Attitudes about Science Survey (CLASS) is not a good fit for the instrument. The present study extends the analysis of Douglas et al. which found a 3-factor solution. Bi-variate correlation and commonality coefficients from Explanatory Factor Analysis (EFA) are used to understand the importance of each item leading to the removal of several items. A Scree test is used to determine the number of factors. Structural Equation Modeling (SEM) is used to understand and improve the scales. Cronbach's alpha coefficients are also calculated. Four scales were identified using twenty-one items, seven items were categorized as unique items, seven items were discarded, and six items were not
red.

B04-02 (10:12 to 10:24 AM Monday) | Contributed Talk | Visualizing Depth of Student Conceptual Understanding Using Subquestions and Alluvial Diagrams

Presenting Author: Jun-ichiro Yasuda, Yamagata University

Additional Author | Michael Malvern Hull, University of Alaska Fairbanks

Additional Author | Naohiro Mae, Osaka University

We aim to graphically and deeply analyze the conceptual understanding behind the FCI responses of students, focusing on three questions (questions 1, 15, and 28). In our study, we created and implemented subquestions to clarify and quantify the students' reasoning steps in reaching their responses to the original FCI questions. We used alluvial diagrams to visualize the responses of students on the subquestions and original FCI questions, representing the transition rates across the question options as flows. By combining subquestions and alluvial diagrams as we did, we are able to efficiently analyze the depth of understanding for a given situation and to visualize the existence of a specific misconception. For example, we found that even among those who correctly answered FCI Q.15 about Newton's third law, many students incorrectly answered a corresponding subquestion asking about whether Newton's third law holds at the end of the interaction between the two objects. This misconception turned out to be fairly robust, as these same students had a similar answering pattern for Q.28. Alluvial diagrams can be used for a broad range of applications, including analysis of multiple-tier tests, testlets, tests for representational consistency (e.g., a representational variant of the FCI), and so on.

B04-03 (10:24 to 10:36 AM Monday) | Contributed Talk | Predictors of Performance in Introductory Physics Courses

Presenting Author: David Meltzer, Arizona State University

Co-presenting Author | Dakota H King, Arizona State University

We have administered a number of diagnostic preinstruction tests to introductory physics students at three campuses of two universities, including measures of mathematical skill, scientific reasoning, and physics knowledge. In addition, we have recently re-analyzed additional related data from two other universities. We find consistently, in every class analyzed, that the top scorers on these pre-instruction tests have substantially higher probability of receiving high course grades (A- or higher) than low-scorers on the tests, typically by a factor of two or more. Similarly, the high scorers have a much lower probability of receiving a low course grade (C+ or lower) than low scorers, again typically by a factor of two or more. Performances on the different predictors are positively correlated, but not perfectly so. The most consistent predictor seems to be pre-instruction score on the Lawson Test of Scientific Reasoning. We note that factors such as motivation, class participation, and consistent effort also appear to play a significant role in course performance.
Supported in part by NSF DUE #1504986 and #1914712

B04-04 (10:36 to 10:48 AM Monday) | Contributed Talk | Evaluating Conscientiousness in Student Responses to Show-Work Exam Questions

Presenting Author: Heather Mei, The Ohio State University

Additional Author | Qiaoyi Liu, The Ohio State University

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 algebra-based and calculus-based introductory physics courses during the fall 2022 semester at a large public research university. We describe a coding scheme for "Show-Work Conscientiousness" (SWC), which include margin spacing, straight lines of work, defining variables, final answer markings, drawing diagrams, clarity and neatness, and report on preliminary findings. Further, we report on results of a brief conscientiousness survey administered to students. Finally, we describe and report on preliminary results of a hypothesized mediation model in which SWC predicts student's show-work exam question scores, and mediates the association between self-reported conscientiousness and students' exam performance.

Session B05: PER: Student Experiences & DEI

Location: Ballroom A06 **Sponsor:** Committee on Research in Physics Education **Time:** 10–11 a.m.
Date: Monday, July 17, 2023 **Presider:** Maajida Murdock

B05-01 (10:00 to 10:12 AM Monday) | Contributed Talk | Framework for Unpacking Students' Experiences in Introductory Physics Part II: Beliefs, Motivations and Emotions

Presenting Author: Sarat Lewsirirat, University of Illinois Urbana-Champaign

Additional Author | Ellen Ouellette, University of Illinois Urbana-Champaign

Additional Author | Ryan Biju Sebastian, University of Illinois Urbana-Champaign

Additional Author | Christina Krist, University of Illinois Urbana-Champaign

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

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

We report on the result of 30 1-hour, semi-structured interviews with introductory physics students conducted to investigate their experiences with our local course structures. This effort is part of a larger course transformation project to increase student success in introductory physics at the University of Illinois. In this talk, we will examine how students' beliefs, motivations, and emotions are tied to their perceptions of course features and will propose that they can reinforce one another in bidirectional ways — students' beliefs, motivations, and emotions can impact their perceptions of course structures, and students' experiences with course structures can impact their beliefs, motivations, and emotions. We will present examples from student interviews to illustrate this bidirectional hypothesis. By understanding how students' experiences arise out of interaction between their own beliefs, motivations, and emotions with specific course structures, we hope to uncover useful design principles for fostering student success and well-being.

B05-02 (10:12 to 10:24 AM Monday) | Contributed Talk | Understanding the Development of Sense of Belonging in an Upper Division Physics Class

Presenting Author: Daniel Pacheco, Florida International University

Additional Author | Geoff Potvin, Florida International University

Sense of belonging is an essential human motivation that has also been shown to be critical to students' success in their undergraduate careers. This study investigates sense of belonging for students enrolled in an upper division physics course. A 23-item survey measuring sense of belonging and other factors related to students' identity was administered in a student-centered Modern Physics course at the beginning and end of the semester. A confirmatory factor analysis was conducted to establish a measure of sense of belonging and the data was tested for significant changes in students' sense of belonging as well as associations to other salient identity outcomes. Findings show that sense of belonging had a significant positive gain over the semester. Also, sense of belonging is significantly correlated with two other factors that have been shown to contribute to physics identity

B05-03 (10:24 to 10:36 AM Monday) | Contributed Talk | The Effects of the COVID-19 Pandemic on Undergraduate Physics Learning

Presenting Author: Amanda Nemeth, West Virginia University

Additional Author | Christopher Wheatley, West Virginia University

Additional Author | John Stewart, West Virginia University

The effects of the COVID-19 pandemic were widely felt, but how did those effects translate in the undergraduate physics classroom upon return to face-to-face learning after nearly a year and a half of remote learning? This presentation focuses on a study conducted at a large eastern United States land-grant university examining these effects. The study compares the last two fully face-to-face semesters pre-pandemic and the first two fully face-to-face post-pandemic semesters of an introductory calculus-based electricity and magnetism course. Measures such as high school preparation (high school GPA, ACT/SAT scores, and conceptual pretest scores), in-class behavior (submission rates for homework and lecture attendance), and in-class achievement (homework and test averages) were examined. While some changes were detected, they were generally small effects.

Session B06: Teaching about How Science is Done in Your Course

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Shahida Dar

B06-01 (10:00 to 10:12 AM Monday) | Contributed Talk | Physics Laboratory Write-ups as Scientific Papers

Presenting Author: Anna DeJong, Howard Community College

It is well documented that inquiry-based labs, otherwise known as discovery labs, are one of the best ways for students to learn. These labs allow the student to experience the scientific process in a more realistic way than a step-by-step approach to laboratory physics. However, the process for producing student laboratory write-up is usually very basic and follows the "scientific method" in a way that has very little connection with the process used in real world scientific research. To address this mismatch, I will outline a novel lab write up format that parallels the process for producing scientific papers and that allows the students to approach science writing like a scientist. This new format also allows the student write-ups to serve as an end-of-the-semester independent project that simulates real-world science. As part of this process, students must also formulate and submit a scientific proposal for their project, providing them an experience common to most research scientists in academia, government, and industry. This new approach to physics laboratory write-ups is currently being integrated into the Howard Community College (HCC) algebra-based Introduction to Physics I & II as part of the curriculum.

B06-02 (10:12 to 10:24 AM Monday) | Contributed Talk | Development of Hypothetico-Deductive Reasoning Skills in ISLE Approach Classrooms

Presenting Author: Danielle Buggé, Rutgers University

Additional Author | Joshua Rutberg, Rutgers Newark

Additional Author | Diane Jammula, Rutgers Newark

The Investigative Science Learning Environment (ISLE) is a holistic approach to learning and teaching that engages students in the practices of scientists as they are learning new material with the goal of the development of scientific abilities. These scientific abilities are interwoven into all facets of learning through ISLE, not just the laboratory component. Prior studies of ISLE approach classrooms have found that learners in introductory physics courses require multiple exposures to the scientific abilities in order to demonstrate proficiency. One ability in particular that students struggle with is hypothetico-deductive reasoning. Hypothetico-deductive reasoning necessitates that students systematically make predictions based on the hypotheses under test. This is challenging because many students want to base predictions off of their own intuition. In this talk, we share how this approach to physics instruction has helped first-year introductory physics students grapple with and exhibit growth with this challenging scientific ability. We will also show how instructor training affects students' progress.

B06-03 (10:24 to 10:36 AM Monday) | Contributed Talk | Examining the Gap Between School Physics and How Physics Is Done

Presenting Author: Benjamin Zwickl, School of Physics and Astronomy, RIT

Additional Author | Dina Zohrabi Alaee, School of Physics and Astronomy, RIT

Additional Author | Ridge Bennett, School of Physics and Astronomy, RIT

Additional Author | Pedro Cardona, School of Physics and Astronomy, RIT

Using interviews with over 40 undergraduate physics majors, we examine ways in which students' learning experiences inside and outside of school shape their holistic perception of physics as a field and their long-term physics interests.The gap between how science is done versus taught will be addressed through five themes. The first addresses how physics is portrayed in popular science media, often emphasizing big ideas and new results, but ignoring the nature of the work behind those accomplishments. Second, we see sharp disciplinary boundaries emerging in high school that discourage interdisciplinary interests, including biophysics. Third, the typical bachelor's curriculum places more emphasis on canonical coursework above contemporary research, meaning students lack awareness of the motivations, methods, and career paths within the physics community. Fourth, many aspects of the bachelor's curriculum emphasize knowing canonical content above contributing to a community, though course projects and research experiences more directly foster participation in a physics community. Finally, students often struggle to make connections between their coursework and their values of doing good, with teaching and outreach being the primary ways that physics can help others. These themes suggest many opportunities for improving the authenticity of physics education.

B06-04 (10:36 to 10:48 AM Monday) | Contributed Talk | Title: Pre-service Teachers' Understandings of Scientific Inquiry

Presenting Author: Ying Cao, Drury University

Additional Author | Edward A. Williamson, Drury University

In this study, we adopt a mixed method approach to learning about pre-service elementary teachers' understanding of scientific inquiry. We developed our questionnaire referencing the National Science Education Standards for inquiry and previous work in the area. Two 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. Between the two rounds of surveying, we revised the survey questionnaire to add two of the interview questions to the survey, as well as some demographic questions. Survey results were analyzed statistically. Interview transcripts were coded qualitatively. Our goal is to compare our study results with the results from studies of a similar topic in a similar geographic area with a similar student population from the beginning of the 21st century, more than 20 years ago, to see if any changes in students' understandings of inquiry. We hope to capture some evolutionary patterns in pre-service teachers' understandings of scientific inquiry and generate implications to elementary science education nowadays.

Session B07: Doing Physics and Being _____ + Decolonizing Physics in the Curriculum

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 10–11:30 a.m. **Date:** Monday, July 17, 2023 **Presider:** Carolina Alvarado

B07-01 (10:00 to 10:24 AM Monday) | | Doing Physics at NASA and Aggressively Rejecting a Gender Binary

Presenting Author: Marshall Styczinski, Jet Propulsion Laboratory, California Institute of Technology

Only within the past 5 years have I been afforded the opportunities I needed to explore my gender identity, sexual preferences, and relationship structure. I now recognize that I am demimale, which is a type of non-binary, and I only engage in consensually non-monogamous relationships. I have always liked to stand out. I now rely on this trait for resolve in navigating everyday environments, including at my workplace, a NASA center. In professional situations, people often express surprise at my competence because it contrasts with their initial expectation. Many people I encounter, mainly outside of work, are actively hostile toward a masculine body adorned with clothing cut or patterned differently than they expect, such as a dress. However, I am frequently rewarded by colleagues and random acquaintances expressing appreciation for my unapologetic demeanor and attire. I will discuss the key factors I have identified in my own journey that stymied my development, the catalyst experiences that enabled me to ask (and answer) tough questions of myself, and the habits I have formed to wield my intentionally strange appearance for constructive purposes.

B07-02 (10:24 to 10:48 AM Monday) | | Examination of Culture-based Approaches to Physics Instruction

Presenting Author: Clausell Mathis, Michigan State University

Many physics teachers have expressed challenges in establishing a culture-based approach to instruction. We highlight the work of physics instructors who have attempted to incorporate Culture-based approaches to instruction in their classrooms. We will describe our methodology and findings on physics teachers' approaches to developing and enacting culture-based physics instruction. Our findings come from exploratory qualitative analysis across three projects: (1) physics teacher identity towards equitable instruction, (2) teacher practice, (3) student learning. Current findings from our studies have implications for the research on equitable approaches to physics instruction.

B07-03 (10:48 to 11:00 AM Monday) | Contributed Talk | Empowering Students through Participant Action Research for Inclusive Physics Curricula Design

Presenting Author: Idaykis Rodriguez, Florida International University

Additional Author | Camila Atencio, Florida International University

Additional Author | Sony Raymond, Florida International University

Additional Author | Tomas Gonzalez, Florida International University

Additional Author | Emiliano Garcia, Florida International University

The algebra-based physics course is often taken by students majors who may be apprehensive of physics and may not enter these classes expecting that physics knowledge will be relevant for their future careers. Motivated to impact student perceptions and attitudes towards physics and decrease their anxiety towards it, this project is designed to explore how to design a curriculum that will be useful for students and its correlation to their career path. Taking a critically inclusive approach, we have recruited students within the course to be co-researchers, and co-developers of materials of this student-centered introductory physics course. In this talk, we will present on the meta-level group dynamics between co-researchers that allows for inclusive research practices and truly explores what it means to empower students when allowing them to share the power. We will also discuss, outcomes of their self-developed research questions of student's perceived utility of physics and perceptions of physics.

B07-04 (11:00 to 11:30 AM) | | Being Multiply Marginalized in Physics

Presenting Author: Geraldine Cochran

Being multiply marginalized in physics means that I identify with multiple groups that are marginalized within physics communities. This means that at times I experience the othering, the isolation, the silencing, and the disadvantages that various marginalized groups face in physics. This has also meant that I have found a community among people marginalized in physics and working to challenge and/erase the practices, policies, and traditionally held beliefs that lead to inequities in the physics community. What is more, intersectionality theory posits that multiply marginalized people may face unique challenges due to being marginalized based on two or more identities. These are experiences that may not be shared by all people with one of those identities. In this presentation, I will share my experience as a multiply marginalized person in physics and discuss how these experiences motivate the work I do in physics education research.

Session B08: Calling TYCs! About OPTYCs: The Organization for Physics at Two-Year Colleges

Location: Ballroom A09 **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 10–11 a.m.
Date: Monday, July 17, 2023 **Presider:** Glenda Denicolo

B08-01 (10:00 to 11:00 AM Monday) | | OPTYCs Mentoring Update

Presenting Author: David Marasco, Foothill College

Additional Author | Renee Lathrop, Dutchess Community College

Part of the Organization for Physics at Two Year Colleges's (OPTYCs) efforts is a mentoring program. This is to counter the isolation experienced by many in the Physics TYC community. The program features "traditional" mentor-mentee pairings, mutual-mentoring small groups for people with shared interests or backgrounds, and communities of practice for workgroups focused on a particular issue or problem. This talk will describe the different types of mentoring relationships, discuss the progress made in the first phase of this project, and recruit new participants into the TYC mentoring ecosystem.

B08-02 (10:00 to 11:00 AM Monday) | | OPTYCS: Revision of the Guidelines for Two-Year College Physics Programs

Presenting Author: Sherry Savrda, AAPT-OPTYCs

The last edition of the Guidelines for Two-Year College Physics Programs, published by AAPT, was released in 2001. An update was started in 2012 but was never completed. These Guidelines are severely out of date. They do not fully incorporate years of what we have learned from the PER community and contain only skeletal guidelines for virtual learning and DEI initiatives. The OPTYCs project is sponsoring the revision of the Guidelines. This presentation will describe the process being undertaken, and the changes being made to help make the Guidelines more robust.

B08-03 (10:00 to 11:00 AM) | | TYC Leadership Institute

Presenting Author: Brooke Haag

Additional Author | Krista E Wood, University of Cincinnati Blue Ash College

Additional Author | Dwain M Desbien, Estrella Mountain Community College

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.)

Session B09: Teaching IPLS – Interactive Poster Session

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Juan Burciaga

B09-01 (10:00 to 11:00 AM Monday) | Poster Presentation Traditional | Injecting Fluids into Your Introductory Physics Course for Life Science Students

Presenting Author: Dawn Meredith, University of New Hampshire

Additional Author | Daniel E. Young, University of North Carolina - Chapel Hill

Co-presenting Author | James Vesenka, University of New England

Co-presenting Author | DJ Wagner, Grove City College

Fluids statics and dynamics are topics you might be tempted to cover lightly in an already packed introductory course for life science students. You might be particularly tempted to leave out viscous fluids, which are not part of the standard physics presentation. Yet life always unfolds in a viscous fluid environment. Understanding fluids, in particular viscous fluids, can help students explain organismal form and function as well as animal behavior. We present the value of fluids to life science students, how you can make time for fluids in a packed course, and how you can lower the barrier to including more fluids topics.

B09-02 (10:00 to 11:00 AM Monday) | Poster Presentation Traditional | Development of Reynolds-Number Questions for the Fluids Conceptual Evaluation (FCE)

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 North Carolina Chapel Hill

Additional Author | Dawn Meredith, University of New Hampshire

This work is part of a multi-institution collaboration developing a fair, valid, and reliable research-based conceptual fluids assessment, the Fluids Conceptual Evaluation (FCE). The FCE will utilize two-tier multiple-choice items covering both fluids statics and fluids dynamics. In this poster we will describe the development of questions probing the constructs involving the Reynolds number. Clinical interviews and a comparison of introductory texts resulted in our combining two constructs and significantly limiting the scope of what we asked, due to the lack of consistency in both coverage and vocabulary regarding the different types of drag forces. IPLS instructors interested in serving as an FCE pilot test site should contact Project Lead Dawn Meredith.

B09-03 (10:00 to 11:00 AM Monday) | Poster Presentation Traditional | Fluids Conceptual Evaluation Update: Sign up for Pilot Test!

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

Additional Author | James Vesenka, University of New England

Co-presenting Author | D J Wagner, Grove City College

Additional Author | Daniel Young, University of North Carolina Chapel Hill/ University of New Hampshire

Co-presenting Author | Dawn Meredith, University of New Hampshire

The Fluids Conceptual Evaluation (FCE) is ready to collect pilot test data during Fall 2023. The development of the FCE involves a collaborative effort among multiple institutions to develop the FCE as a reliable, valid, and fair two-tier multiple-choice instrument covering both fluids statics and dynamics. After creating multiple Tier 1 conceptual items and studying the reasons behind students' responses, the next step is to pilot test the items and determine which ones to include in the final FCE. This poster presents an overview of the FCE and its various items, along with details about the planned Pilot Test for Fall 2023. The project team is currently seeking multiple institutions that offer introductory physics courses for life science majors, with or without fluids to participate in the pilot test. If you're interested in participating in the FCE pilot test this fall, please reach out to the project lead, Dawn Meredith, at dawn.merdith@unh.edu.
Project supported by NSF 2021273, 2021059, 2021261, and 2021224

B09-04 (10:00 to 11:00 AM Monday) | Poster Presentation Traditional | IPLS Scenario Activities to Increase Student Engagement and Learning

Presenting Author: Nancy Beverly, Mercy College

To support class engagement for everyone, students work on digital worksheets of life scenarios in groups but submit individually. Whole class discussion follows using examples from volunteers. The homework scenarios are similar, so students are motivated to learn by doing the practice ones in class. These scenarios are centered in life and health contexts to align with IPLS student interests, and they typically have data to be interpreted or used in algebraic models to make some inference concerning the scenario phenomenon. The classroom has become a more relaxed learning environment, all the groups become animated when doing these scenarios, and students do better on the homework now as well.

B09-05 (10:00 to 11:00 AM Monday) | Poster Presentation Traditional | The Premeds Dilemma: Pedagogy vs. Prudence in IPLS

Presenting Author: Jason Puchalla, Princeton University

The past decade has brought a significant convergence in the pedagogy used for STEM physics and Introductory Physics for the Life Sciences (IPLS) courses. However, two features distinguishing IPLS students from traditional STEM majors are their greater academic diversity and the existence of several distinct cohorts. Both of these factors are difficult to quantify and continue to evolve. In terms of cohorts, premedical students often make up a significant fraction of IPLS enrollment and bring both explicit and implicit challenges to course design. Moreover, academic environments are highly school-dependent, further confounding the development of a widely adoptable balance between IPLS pedagogy and the prudent premedical student's expectations. Here we review some of the primary considerations weighed by students and instructors, including current trends in premedical physics requirements and the role of advising. We also present an overview and some key results of an unorthodox approach to balancing these considerations developed at Princeton University over the past six years.

B09-06 (10:00 to 11:00 AM Monday) | Poster Roundtable | Characterizing Biomechanical Movement, the Cardiac Cycle, Physiological Tremors, and Blood Flow Using the Sensors in your Smartphone

Presenting Author: David Rakestraw, Lawrence Livermore National Laboratory

In this interactive session, participants will conduct investigations of biomechanical processes using various sensors every student has on their smartphone. These investigations allow students to learn about displacement, velocity, acceleration, rotational motion, and light. Every participant will actively investigate: 1) biomechanical motion of their arm by measuring the acceleration which in turns allows precise determination of velocity and displacement, 2) vibrations produced by the cardiac cycle enabling the identification of atrium/ventricle contractions, value opening/closing and peak blood flow, 3) physiological tremors of their hands which behave like a harmonic oscillator, 4) transport of blood to and from their fingers using reflectance spectroscopy, and 5) their gait using accelerometers and gyroscopes to characterize the details of each step. Each of these "experiments" enable an in-depth laboratory activity which educators can implement in their classrooms or assign students to do at home. The activities are designed to capture the interest of life science students, demonstrate the connection of physics phenomena to the understanding of biological process, and motivate students to think how they might use physics to drive future innovations in medicine and life sciences. Participants will be directed to more detailed resources on the topics, which are all freely available. I think this would be great as an activity where all the participants can make the measurements on their own. None of these activities require anything other than a free application on their phones. I will bring 10 extra phones with the applications included for people who desire that option. This work is part of Lawrence Livermore National Laboratory's STEM outreach program. All the materials that educators need are available for free at: https://st.llnl.gov/sci-ed/Physics-with-Phones

B09-07 (10:00 to 11:00 AM Monday) | Poster Roundtable | To B(ernoulli), or not to B(ernoulli): when Hagen Poiseuille misses the mark.

Presenting Author: James Vesenka, University of New England, Biddeford ME

The dynamic Bernoulli pressure drop (BPD) equation is a mainstay of the all too brief coverage of fluids afforded in most traditional introductory college physics courses. The Introductory Physics for the Life Science (IPLS) community recognizes that the Hagen Poiseuille pressure drop (HPPD) plays a more important role when describing pressure drops in authentic biological systems (Moser 2021). There is one important exception: blood flow near the heart. Under typical blood flow speeds near the heart the BPD in arteries is observable, though still less than HPPD. We present a simple fluid circuit using inexpensive plastic tubing and three-dimensional printed splitters designed to minimize turbulent mixing by fluid impedance matching, i.e., smoothly splitting and recombining fluid flow. In this mid Reynolds number domain simulations using both BPD and HPPD can qualitatively map the observed pressure drops but make predictions too low by almost an order of magnitude. We discuss sources of this aberrant behavior that appears to contribute even greater pressure drops in the circuit than the commonly assumed contributions of Bernoulli and Hagen Poiseuille, and the impact in understanding the circulatory system
Moser, Bradley Teach Poiseuille First — A Call for a Paradigm Shift in Fluid Dynamics Education. The Physics Teacher, Volume 59, Issue 7, p.552-555

B09-08 (10:00 to 11:00 AM Monday) | Poster Roundtable | Assessment of Standards-based Grading in Introductory College Physics

Presenting Author: Travis Oliver, Western Kentucky University

How does one address issues of equity without lowering standards in a diverse student population, such as those often found at non-selective institutions? For several years we have implemented standards-based assessment in our introductory physics for life science course to address issues of equity in a classroom with different levels of student preparation. Standards-based assessment is a mastery learning approach where students can reassess multiple times on course learning objectives and learn from the feedback. However, there has been only limited research on the impact, dynamics, and student response to standards-based assessment in college-level physics. This poster will describe both our implementation of standards-based assessment in a quasi-flipped, active learning classroom with weekly quizzes tied directly to learning objectives, and our evaluation of this model through pre/post-conceptual testing, self-efficacy surveys, and tracking student development through evaluation of course work. We will use this analysis to identify aspects of the model that were effective and those that can be improved with a goal of sharing that information with other educators who might utilize such approaches in their classrooms.

B09-09 (10:00 to 11:00 AM) | Poster Presentation Traditional | Developing a Reynolds Number Tutorial

Presenting Author: Brandon Lunk, Texas State University

Additional Author | Jessica Hobbs, Texas State University

Reynolds Number is a critical metric in both physics and biology for determining the flow characteristics of fluids at various scales. Understanding these flow patterns can lend insight both into the mechanisms behind organismal structures like wings, gills, and vascular systems, but also into broader biological processes such as adaptedness and natural selection. For these reasons, many IPLS curricula have begun including Reynolds Number among their content coverage. However, the simplicity of having a single index to determine flow patterns hides a considerable complexity in the analysis of fluids and their impact on biological structure. To help students with this, we have been developing a Tutorial-style worksheet on Reynolds Number and motion in viscous fluids. In this session, I (BRL) will present the working status of this worksheet along with a discussion of our design principles and pedagogical goals, and observations from field-testing this tutorial in class. I will also use this session as an opportunity to solicit community feedback for the further refinement of this activity: are there features of Reynolds Number that we should be including or omitting? What student difficulties should we anticipate? How best to connect these ideas to biological applications?

Session B10: Accessible Lab Equipment

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Max Nam

B10-01 (10:00 to 10:12 AM Monday) | Contributed Talk | Designing, Constructing, and Testing a Custom Apparatus to Investigate Angular Momentum and Torque

Presenting Author: Aaron Titus, North Carolina State University

Additional Author | Jenny Aguirre, High Point University

This project is a continuation of work to develop a custom apparatus to investigate angular momentum and torque. This version of the apparatus has two motors fixed at the end of a beam. A microcontroller controls the angular velocity of the motors. Through a web-based interface, the user can change the angular momentum of the disks and study the effect on the angular momentum of the beam. For this version of the apparatus, we measured its moment of inertia using two different experimental designs. In a future version, we will add sensors for measuring the angular speed of motors and the beam, and we will measure the torque due to drag on propellers.

B10-02 (10:24 to 10:36 AM Monday) | Contributed Talk | Applications of 3D Printing for Creating Budget-Friendly Physics Labs and Demonstrations

Presenting Author: Hunter Reaves, Arizona State University

Additional Author | Nik Awtrey, Arizona State University

Additional Author | Brandon Gaydusek, Arizona State University

Additional Author | Jesse Sakstrup, Arizona State University

The transformative potential of 3D printing expands the accessibility and affordability of specialized physics lab equipment. In this presentation we demonstrate how our group at Arizona State University's Physics Instructional Resource Team (ASU PIRT) has developed cost-effective alternatives for physics labs and demonstrations using 3D printing. The objective of a given lab activity imposes requirements on equipment design; we outline the imposed requirements and show how they are met via two worked examples: a projectile launcher and electric field plotting apparatus. We compare our designs against their pricier, commercial counterparts, and give an overview of the process we used to design and print these objects.

B10-03 (10:36 to 10:48 AM Monday) | Contributed Talk | Pendulums

Presenting Author: Lenore Horner, The Seven Hills School

Simple pendulum labs are a staple of introductory labs. Good hangers help students get good data. I will illustrate an easily 3D printable version (that can also be cut easily from wood). Similary, an accurately strung Newton's cradle makes the elastic collision demonstration clearer. I will illustrate a laser-cuttable (plus hardware) version that adjusts quite nicely and is easily restringable.

Session B11: Updates from PICUP: Integrating Computation into Undergraduate Physics

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Marie Lopez del Puerto

B11-01 (10:00 to 10:12 AM Monday) | Contributed Talk | Addressing Student Difficulties with Visual Python in University Physics

Presenting Author: Hannah Kramer, Western Kentucky University

Additional Author | Scott W Bonham, Western Kentucky University

We integrated Visual Python (VPython) into University Physics courses several years ago as part of adopting the Matter & Interactions curriculum. However, students have consistently struggled in translating physics principles into functional VPython code. New curricular materials for the laboratory component were developed and evaluated in the Fall of 2022 to provide students with more familiarity and support through prelab questions and worksheet guides. However, evaluation of student work and surveys showed that previous coding experience was the biggest factor in student success with and perception of VPython assignments. In response, we developed additional in-class assignments for use in the lecture component. These assignments scaffold student learning as they first write out physics principles algebraically, next translate to code for implementation, and finally use their simulations and graphs to answer physics questions. Preliminary results from piloting these materials in one lecture section indicate that these new classroom activities improve student learning.
Supported by WKU Faculty Undergraduate Student Engagement Grant

B11-02 (10:12 to 10:24 AM Monday) | Contributed Talk | Space Elevator Analysis for Introductory Physics

Presenting Author: Larry Engelhardt, Francis Marion University

For several years, I have assigned a project where students analyze the stresses within a (model) space elevator. This is a sophomore-level course in computational methods for physics and engineering, and the model space elevator provides a very nice example of where a computer model of a complex system can be built by starting with a simple system, and iteratively stepping through a simple analysis. Specifically, we treat the space elevator as a stack of blocks, and analyze the 1D free body diagram for a single block, and then repeat this process within a loop. The results of this analysis can be compared with the results in Ref. 1, and agree perfectly. The only difference is that Ref. 1 uses symbolic integrals to analyze the space elevator, whereas my students analyze the space elevator using a discrete summation. This assignment will be submitted to the PICUP Collection for you to access the complete details.[2]
1. American Journal of Physics 75, 125 (2007); doi: 10.1119/1.2404957
2. The PICUP Collection, www.compadre.org/PICUP

B11-03 (10:24 to 10:36 AM Monday) | Contributed Talk | Making our Introduction to Computational Physics Course More Equitable and Engaging with Respect to Previous Coding Experience

Presenting Author: Joss Ives, University of British Columbia, Vancouver

Additional Author | Anna Nikou, University of British Columbia, Vancouver

Additional Author | Jaden Majid, University of British Columbia, Vancouver

Additional Author | Ksenia Khoroshun, University of British Columbia, Vancouver

Additional Author | Aaron Kraft, University of British Columbia, Vancouver

At the University of British Colubmia, Vancouver, our second-year Introduction to Computational Physics course has been awarded an internal Students as Partners in Course Design grant to make this course more equitable and engaging with respect to previous coding experience. The core partnership is made up of the co-authors: three undergraduate students, one graduate student and one faculty member. Based on self-reported student data and course grades, we see that a lack of previous coding experience is proving to be a barrier to student success in this course. We will present on our partnership processes as well as details of the redesign of our course structure, instructional materials and assessments to meet the dual challenges of providing appropriate support to novice coders while also providing an engaging course for all learners.

B11-04 (10:36 to 10:48 AM Monday) | Contributed Talk | Computational Data Science with Jupyter Notebooks in Online Courses

Presenting Author: Alexander Shvonski, Massachusetts Institute of Technology

Additional Author | Philip C Harris, Massachusetts Institute of Technology

Modern computational methods are increasingly becoming an essential tool throughout physics. However, their practical use within Physics is often built upon combined knowledge of computational methods and physics that are taught separately. We present a course that provides realistic, contemporary examples of how computational methods apply to physics research, and deliver this content via interactive Jupyter notebooks. This course, titled "Computational Data Science in Physics," was delivered in several different modalities from 2021 to 2023, ranging from online modules on the MITx Online platform (using Open edX), to a full semester, graduate-level course at MIT. For the online modules, we developed interactive problem graders for coding problems and organized content to promote active learning (e.g., lecture videos intermixed with exercises). Each module culminated in a Final Project, where students applied what they had practiced in previous lessons towards a recent (Nobel prize winning) data set (e.g., LIGO and LHC data). Importantly, we ensured that notebooks were accessible to learners in several formats in order to broaden the modes with which learners could engage with the content.

Session B12: Panel: Diversifying your PER Student Subjects for Inclusivity

Location: Meeting Room 03 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Monday, July 17, 2023 **Presider:** Kris Lui

As highlighted in the 2020 paper by Stephen Kanim and Ximena Cid, PER results are currently limited to a subset of the entire student body who receive college-level physics instruction. To broaden the impact of PER results, more representative student samples are needed. Including more of the student body makes PER studies relevant to traditionally excluded students. One approach to diversifying the impact and relevance of PER is to include students taking physics classes at two-year colleges. In this panel discussion, we present ways that existing PER groups can reach out to, and work with two-year college faculty and students.

Session B13: TYC: Discourse in your Classroom

Location: Meeting Room 09 **Sponsor:** Committee on Physics in Two-Year Colleges

Time: 10:30–11:30 a.m. **Date:** Monday, July 17, 2023 **Presider:** Dwain Desbien

This workshop will focus on what we as instructors can do to improve student discourse in our classes. You will experience the techniques as you learn and hopefully will come away with a few new tools to use in your own classroom. This workshop will be interactive and engage you in the process of developing discourse.

PLENARY: Challenges and Innovations for Inclusive Assessments for Blind Students in STEM, *by Cary Supalo, Educational Testing Service (ETS)*

Cary Supalo

In a recent collaboration, the Educational Testing Service and the Carnegie Foundation announced this new refocus on skills development in assessment – a priority that will redefine how STEM assessments are designed and conducted in the United States. This zeitgeist and its new innovative access technologies will make more inclusive STEM assessments possible. What then is inclusive assessment design? The answer varies depending upon the respondent to this deep question. This presentation will describe where we are today with assessments, how new innovative technologies are shifting the needle towards assessments for skill development and away from time-based approaches, and discuss some innovations on the horizon. Inclusive assessment design works in conjunction with inclusive curricula. As textbook publishers and science education technology firms become more inclusively minded, so too will the STEM subject fields. As STEM industry standards shift towards inclusion, so too must the education profession. Inclusion can and will be the future of STEM education.

AAPT PHYSICS EDUCATION®

Monday, July 17

11:30 a.m.–12:30 p.m.

Ballroom A01

Session C01: Social Media to Connect Teachers

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Gay Stewart

C01-01 (2:00 to 3:00 PM Monday) | | Reimagining Professional Development with Social Media

Presenting Author: Tiffany Taylor, Rogers High School

Many of the formal professional development opportunities we experience as physics teachers are not designed to be physics-focused experiences. Rather, they are general in nature, or lacking in robustness, or both. In this talk, I will share how we can reimagine professional development to include social media as an informal means of professional growth. Social media groups for physics teachers offer real-time support for content-related instruction, (e.g., lessons, demonstrations, and laboratory activities), as well as support for pedagogical or philosophical shifts in thinking (e.g., assessment practices, instructional practices). As the "physics family we chose," social media groups for physics teachers provide a connection that allows us to grow professionally on our own schedule, to learn more about what we are passionate about and interested in, and to experience sustained mutual support beyond a one-day or single event.

C01-02 (2:00 to 3:00 PM Monday) | | Virtual Communities for Mutual Support

Presenting Author: Marta Stoeckel, North St. Paul - Maplewood - Oakdale Public Schools

A significant predictor of whether a teacher will maintain a major shift in instructional practice is whether the teacher has ongoing support for that change. In this talk, I will share how the communities I have built through social media have ensured that I have that support for making changes to my own instruction. Connections I made on Twitter not only helped me find new ideas for my classroom, but lead to deeper conversations including a virtual professional learning community (PLC), an organically organized virtual book study, and feedback on lessons I shared on a 180 blog. I will discuss how these experiences have helped to shape my instruction and have translated into in-person connections and experiences that have been important to my professional growth and in sustaining and deepening my efforts to make my instruction more equitable and more student-centered.

C01-03 (2:00 to 3:00 PM Monday) | | Using Social Media to Grow as a Physics Educator

Presenting Author: Bree Barnett Dreyfuss, Amador Valley High School

Everything from new labs, cutting edge technology to student behavior trends is shared on teacher social media. It can be intimidating seeing "highlight reels" of successes and can quickly become an echo chamber if you only follow those suggested for you by algorithms. Social media gives us the opportunity to expand our circle of influences and learn from different voices. Following teachers and scientists from different areas, backgrounds and fields of study can contribute much to your teaching. Sharing our difficulties, our ideas yet to be tried and our works in progress is also important as a community. There is a large body of knowledge across physics social media communities, spanning generations of teachers and decades of teaching experience, that can be leveraged on social media for everything from solving problems to identifying antique equipment. Everyone can learn from each other when we are open and willing to learn from each other.

C01-04 (2:00 to 3:00 PM) | | Connecting with Other Teachers Through Social Media

Presenting Author: Tiffany Taylor

Social media can be a powerful tool for physics teachers' professional growth when used to connect with colleagues, especially for teachers who do not have other physics teachers geographically close to them. This interactive portion of the session will follow talks from three teachers on their use of social media and focus on strategies and tools to locate and participate in high school physics teacher communities on several popular social media platforms. The speakers will share some of our approaches and strategies, but participants will also have the opportunity to explore these platforms, share their own experiences using social media to improve their teaching practice, and connect with other teachers interested in virtual communities and collaborations.
This portion of the invited talk is interactive

Session C02: 21st Century Physics in the Classroom

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Jim Rantschler

C02-01 (2:00 to 2:12 PM Monday) | Contributed Talk | Microwave Plasma Generation Technique, Its Application and Integration in EM Modules in Regular Classroom

Presenting Author: Kausik Das, University of Maryland Eastern Shore

A simple and inexpensive method to generate plasma using a kitchen microwave oven is described in this presentation. The microwave-generated plasma is characterized by spectroscopic analysis and compared with the absorption spectra of a gas discharge tube. A Paschen-like curve is observed as the microwave plasma initiation time is plotted as a function of the pressure of the plasma chamber. We have also demonstrated that this microwave-generated air plasma can be used in a multitude of applications such as: (a) surface modification of a substrate to change its wettability; (b) surface modification to change electrical/optical properties of a substrate; and (c) enhancement of adhesive forces for improved bonding of polymeric microfluidic molds, such as bonding polydimethylsiloxane (PDMS) chips to glass covers. These simple techniques of plasma generation and subsequent surface treatment and modification applications may bring new opportunities leading to new innovations not only in advanced labs, but also in undergraduate and even high school research labs. EM based concept cartoon clicker questions were drawn to integrate this research in regular clasroom teaching.

C02-02 (2:12 to 2:24 PM Monday) | Contributed Talk | Visualizing Special Relativity

Presenting Author: Lewis McIntyre, retired

This presentation will introduce a new methodology for solution of problems of Special Relativity, up to and Including mass, momentum, energy, and kinematics, using a simple polar plot. Unlike other graphical solutions, all reference frames are orthogonal and of equal measure, so multiple reference frames can be presented simultaneously. This presentation will be time-limited to the construction of the velocity triangle, central to the methodology, and example solutions of the Lorentz Transform. This methodology uses simple graphics and trigonometry, allowing the Special Theory to be visualized, and amenable to the teaching of the Special Theory at the high school level.

C02-03 (2:24 to 2:36 PM Monday) | Contributed Talk | Integrating Imaging Physics into Undergrad STEM Education

Presenting Author: Bethe Scalettar, Lewis & Clark College

Additional Author | James R. Abney, Psi Star Intellectual Property LLC

Physics is a notoriously challenging subject that plays a critical and ubiquitous role in our lives. Undergraduate educators thus need new approaches that will encourage college students to study physics. We have addressed this need through the development of a novel undergraduate physics course and associated textbook that cover the principles, practice, and application of prominent biomedical imaging techniques (i.e., light microscopy and medical imaging) and explore their extensive connections to physics. We chose to focus on imaging because it is a powerful, ubiquitous scientific tool that has strong foundational ties to physics. Imaging also arises frequently in everyday life, so students are interested in the topic and appreciate its importance. The physical foundations of imaging can be established using approaches that range from purely conceptual to highly theoretical. We use a combined conceptual and theoretical approach that is enthusiastically received by students majoring in all STEM disciplines. This success suggests that other institutions also would profit from offering a course focused on biomedical imaging. Here we describe the course content, including highly popular hands-on activities, to help pave the way for other educators who are interested in teaching a similar course.

Session C03: Effective Practices for Developing Scientific Thinking, Reasoning and Decision-Making Abilities in Labs

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Stephen Irons

C03-01 (2:00 to 2:12 PM Monday) | Contributed Talk | Scaffolding Laboratory Skills, Techniques, and Scientific Thinking. An Experimental Approach

Presenting Author: Stephen Irons, Yale University

Additional Author | Eduardo da Silva Neto, Yale University

In Spring 2023 we introduced a significant change in our 1st semester introductory lab for physics majors. We wanted to promote objectives and learning goals that emphasized skills, techniques, and modes of thinking that are not taught in your standard lecture class. We took our standard curriculum and removed a number of experiments to make room for a two part lab experience. In the first half of the semester, we focus student learning on two things: 1. learning how to use and not abuse laboratory equipment such as meters, power supplies, function generators, and oscilloscopes; and 2. understanding how to properly collect data with a computer and analyze it using modern tools (Python, Matplotlib). During the second half of the semester, we focused on a single piece of apparatus where we asked students to perform increasingly complex and more accurate measurements to reveal subtle differences between an initial hypothesis and their collected data. We will also present some preliminary data on student response and compare it to years prior to the change.

C03-02 (2:12 to 2:24 PM Monday) | Contributed Talk | Testing Expectations on Scientific Argumentation in an Online Physics Laboratory

Presenting Author: Yuri Piedrahita, Purdue University

Co-presenting Author | N Sanjay Rebello, Purdue University

Co-presenting Author | Carina M Rebello, Toronto Metropolitan University

The National Research Council (NCR 2012) highlighted scientific argumentation as part of the core for students to engage and understand the real work of scientists. The physics laboratory is a very suitable environment for analyzing the skills of students in performing the use of scientific argumentation (claim, evidence, reasoning) when they are pursuing different hands-on experiments which require overcoming challenges and decision-making. We analyzed the use of scientific argumentation by first-year engineering and science college students in a large cohort of an online physics laboratory in a Midwest R1 university. We had initial expectations and assumptions about the skills of the students to write scientific arguments, and we were able to compare them to the testing results from this study. The handout reports designed for this study scaffolded the students in scientific argumentation during half of the semester. We will discuss the results of our study on student written argumentation.

C03-03 (2:24 to 2:36 PM Monday) | Contributed Talk | Signal vs. Noise: Lies in the Undergraduate Physics Laboratory

Presenting Author: John Elwood, East Stroudsburg University of Pennsylvania

Science educators are understandably frustrated when poorly supported opinion outcompetes evidence-based conclusions in the public milieu. Many would argue that data-driven argumentation is among the most valuable skills developed in the undergraduate laboratory, and imagine that the laboratory experience provides their students at least a partial inoculation against unsupported reasoning. Yet even for science majors and even after extensive instruction, the ability to give priority to data remains elusive. As part of an ongoing eight-semester study, we test the ability of undergraduate laboratory students, armed with data and faced with demonstrably false claims, to resist the whispers and reject false claims. The context chosen is a simple and familiar measurement on a laboratory course final examination. After examining the evidence for suggestion-induced bias overall, we assess the relative impact of in-person laboratories vs. remote laboratories and consider also the evidence for post-measurement data manipulation among the study's participants.

C03-04 (3:36 to 3:48 PM Monday) | Contributed Talk | Assessing Scientific Thinking in an ISLE-based Introductory Lab Course

Presenting Author: Joshua Rutberg, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

Over the past 4 years we have reformed our introductory physics program using the ISLE approach to emphasize the development of scientific reasoning. Our goal is for students to develop the hypothetico-deductive reasoning skills needed to construct and test their own ideas about novel phenomena. In this talk we will discuss how our lab classes are structured to give students opportunities to practice all aspects of these skills. We will also discuss the tool we have developed to help students focus on these skills when writing about their experiences in lab: experimental sentence summaries.

C03-05 (3:48 to 4:00 PM Monday) | Contributed Talk | On the Use of a Meta-report as Instruction for How to Write a Lab Report

Presenting Author: Lars Hellberg, Chalmers University of Technology

This contribution describes a method to help students in a project-based physics lab course in the second year of an physics-major program at the university to write reports according to the IMRAD model. The usual situation is that there is a separate description of what the different sections, for example the abstract or the method section, of a (technical) report should contain. Our experience is that it is often peculiarly difficult for the students to interpret these instructions, which leads to a lot of questions regarding the report writing itself to us teachers. Instead, we have created a Meta Report according to the IMRAD model where the various IMRAD sections do not contain any physics but only detailed information about what is expected to be found in the IMRAD sections of the actual student reports. This may seem like a subtle difference compared to the previous separate instructions, but the Meta Report method has resulted in a clear reduction in the number of the questions we get from students regarding the writing of the reports. In fact, they have largely ceased.

Session C04: PER: Building a Community of Practice

Location: Ballroom A05 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Kelby Hahn

C04-01 (2:00 to 2:12 PM Monday) | Contributed Talk | Considering the Departmental Action Leadership Institute as a Community of Transformation: What's Highlighted and What's Missed?

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 | Fatima Abdurrahman, University of Maryland, College Park

The Communities of Transformation (CoTs) framework is a variation on Communities of Practice that models groups aimed at changing existing practices within institutions by challenging underlying value systems. As new initiatives are developed within Physics to promote institutional change, the CoT framework has the potential to help provide insight into these organizations. We will share our results from applying this framework to the Departmental Action Leadership Institute (DALI). DALI supports physics faculty in leading change efforts in their departments. DALI change leaders are apprenticed into effective change strategies through sustained DALI programming while enacting these strategies within their own Departmental Action Team. In this presentation, we share how DALI aligns with the three core elements of the CoT framework; (a) challenging existing values and adopting new philosophy, (b) offering space for observing and living the new practice, and (c) networking with a community to help enact new practice. Drawing from DALI, we will present specific examples that speak to these core elements and reflect on what implications this may have for DALI going forward. We will also share our reflections on the affordances and constraints that come with applying the CoT framework in DALI and other spaces beyond DALI.

C04-02 (2:12 to 2:24 PM Monday) | Contributed Talk | Recognizing Dominant Cultures Around Assessment and Educational Change in Physics Programs and Apprenticing into Alternatives

Presenting Author: Diana Sachmpazidi, University of Maryland, College Park

Additional Author | Chandra Turpen, University of Maryland, College park

Additional Author | Jayna Petrella, University of Maryland, College Park

Additional Author | Robert P. Dalka, University of Maryland, College Park

Additional Author | Fatima Abdurrahman, University of Maryland, College Park

Physics departments may face challenges regarding student retention and a lack of diverse student representation. In an effort to address challenges, many engage in programmatic change efforts that are challenging and may require a second-order change to be effective. Physics faculty who are responsible for carrying out these efforts may not be prepared with the necessary experience and support to do so. Moreover, there is a limited understanding of the culture within physics programs, a critical aspect that shapes change efforts. The American Physical Society (APS) developed the Departmental Action Leadership Institutes (DALIs) to support physics faculty in learning to effectively design and implement departmental change. In this project, we developed case studies of five DALI-active physics programs across two cohorts. We see evidence of DALI participants becoming aware of taken-for-granted assumptions about educational change processes and assessment practices

within their departmental cultures and coming to recognize and value alternative ways of collaborating and enacting change in their local contexts. This study lays the ground to explore critical aspects of the dominant physics culture that may constrain enacting particular forms of programmatic change and how specific forms of professional development can build departments' capacity for pursuing second-order change.

C04-03 (2:24 to 2:36 PM Monday) | Contributed Talk | What is a Metacognitive Coach?

Presenting Author: Jonathan Kustina, University of New Hampshire

Additional Author | Dawn Meredith, University of New Hampshire

At the University of New Hampshire, peer coaches are undergraduate peer educators who help facilitate learning in introductory STEM classes, either as learning assistants or peer-led team learning leaders. Peer coaches' facilitation is generally focused on specific content knowledge, but their pedagogical skills could be applied to different content as well. Metacognition, an individual's awareness and management of their own thinking and reasoning, is an important skill for undergraduate students to learn, though these practices rarely receive the explicit focus required for sustained implementation. Peer coaches could potentially act as facilitators for metacognitive practices with their introductory STEM students, acting as "metacognitive coaches." As a first step to investigating this new role, we collected written artifacts over a semester from the peer coaches' pedagogical training course. Using this data, we analyzed the metacognitive perspectives of two peer coaches to derive a preliminary operational definition of a metacognitive coach.

C04-04 (2:36 to 2:48 PM Monday) | Contributed Talk | Principles for Building and Maintaining Equitable Partnerships between Researchers and Programs at Two-Year Colleges

Presenting Author: Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State Univesrity

Additional Author | Angela Little, Michigan State University

Additional Author | Laura A. H. Wood, University of Michigan

Building and sustaining equitable partnerships between researchers and partners at two-year colleges (TYCs) takes active and intentional work that is often hidden and unarticulated (Eddy & Amey, 2010). We have been engaged in this partnership work in coordination with a National Science Foundation S-STEM grant for the past 6 years across two TYCs within Michigan. We are now embarking on building a new partnership with a TYC as part of a Howard Hughes Medical Institute Inclusive Excellence 3 project. Establishing this new partnership requires us to name the principles we have used to build and maintain relationships with our existing TYC partners. Some of the principles we have articulated include follow the leader, ask ask ask/listen listen listen, and balance sustainability across sites. In this presentation we will describe these three partnerships and the principles we have used in the relationship work. Our aim is to share these principles as a guide for ourselves and others in the intentional work of building partnerships with TYCs.

This work was supported in part by National Science Foundation (#1742381) and by a grant to Michigan State University from Howard Hughes Medical Institute under the Science Education Program.

Session C05: PER: Methodology

Location: Ballroom A06 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Constance Doty

C05-01 (2:00 to 2:12 PM Monday) | Contributed Talk | Research on a Faculty Support Program for Working With Learning Assistants

Presenting Author: Adrian Juanson, San Jose State University

Additional Author | Gina M Quan, San Jose State University

Learning Assistant Reflection, Guidance, and Exploration (LA-RGE) is a new program at San José State University designed to provide support for university faculty working with learning assistants (LAs). Faculty in LA-RGE attend facilitated bi-weekly meetings throughout the semester which discuss various topics about pedagogy, LAs, and equity. In this presentation, we will discuss a research study on what kind of support is being provided by this program and how that can potentially lead to better partnerships between faculty and LAs. During one-on-one interviews, we asked faculty to discuss their personal experiences over the time they have worked with LAs, and if LA-RGE meetings have had any effect on their perspective and relationship with their LA. We then categorized the different effects and support that faculty were receiving through LA-RGE. This work will be important toward understanding how support for faculty can lead to a more productive partnership between faculty and LAs.

C05-02 (2:12 to 2:24 PM Monday) | Contributed Talk | A Qualitative Method in Education Research Instructor Practices and Epistemology: Domain Analysis on Course-based Undergraduate Research Experiences

Presenting Author: Carolina Alvarado, California State University, Chico

Co-presenting Author | Laura Ríos, California Polytechnic State University, San Luis Obispo

Course-based undergraduate research experiences (CUREs) have been established in the literature as important potential conduits for hands-on learning, professionalization, and to address equity gaps in STEM courses. However, CUREs are often time- and resource-intensive, especially for instructors developing new course material. From a qualitative perspective, many interesting questions arise: How and what do instructors adapt from their research identities and perspectives into their pedagogical intentions? What epistemological assumptions do they enact during CURE, distinct from other types of project-based lessons? Tracking the pathway from intention or belief to a physical or concrete instructional practice is critical in developing ways to support faculty in developing high-quality CUREs. Here, we present a method for qualitative coding, adapted from software engineering, that maps the values, functions, and purposes of a belief to a decision. Our context are CUREs from mathematics, computer science, and physics introductory courses with high drop-withdraw-fail (DFW) rates. ‘

This material is based on work supported by the National Science foundation under Grant No. EES-1953751

C05-03 (2:24 to 2:36 PM Monday) | Contributed Talk | Draft of Referee Guidelines to Maintain Clarity and Generativity of Quantitative Research Studies in PRPER

Presenting Author: Tim Stelzer, University of Illinois

Additional Author | Eric Brewe, Drexel University

Additional Author | Andrew Heckler, Ohio State University

Additional Author | Rachel Henderson, Michigan State University

Additional Author | Eric Kuo, University of Illinois

Physics education research faces statistical analysis challenges that are relatively unique in the physics community. Currently, there are not clear standards for how these challenges should be addressed by researchers and evaluated by peer reviewers in Physical Review Physics Education Research (PRPER). In an effort to move towards more consistent publication standards, the PRPER editorial board formed a Statistical Modeling Review Committee. The charge of this committee is to identify these key challenges and lead the PER community in creating a set of review guidelines to help researchers and referees maintain consistent publication standards for quantitative research. Overall, these review guidelines aim to ensure that authors provide justified interpretations of their studies and share enough information about their studies to encourage replication, extension, and meta-analysis. This talk will provide a preliminary draft of some of these guidelines with the goal of promoting discussion and getting feedback from members of the community.

C05-04 (2:36 to 2:48 PM Monday) | Contributed Talk | The Tools Necessary to Link Mixed-Methods Data Sources Sources: An investigation of Students' Self-efficacy

Presenting Author: Dena Izadi, Michigan State University

Co-presenting Author | Vashti Sawtelle, Michigan State University

Co-presenting Author | Rachel Henderson, Michigan State University

The development of a student's Self-efficacy (SE) is complex and limited research has investigated how SE changes over time and what particular events best support building SE for undergraduate students. SE is traditionally measured by distal accounts of students' experiences through interviews reflecting back over experiences. The advent of Experience Sampling Method (ESM) data collection in self-efficacy raises questions about how to get more proximal reflections. Our team has been running a mixed-methods study examining how SE changes using the ESM survey data combined with daily qualitative journal prompts. In this presentation, we use a qualitative lens to investigate how students' responses to the daily journal prompts correlate with their ESM survey responses. Here, we will discuss the methodology and tools necessary to link the quantitative data source with the qualitative data source in order to understand students' experiences in higher education.

Session C06: Student-Ready Physics in Your Course

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Jason Puchalla

C06-01 (2:00 to 2:12 PM Monday) | Contributed Talk | Measuring Impacts of Supplemental Materials on Student Learning

Presenting Author: Dawson Nodurft, Texas A&M University

Additional Author | Matthew Lee, Texas A&M University

Additional Author | Jonathan Perry, University of Texas at Austin

Additional Author | Tatiana Erukhimova, Texas A&M University

Additional Author | Kevin Black, Texas A&M University

Additional Author | Carlee Garrett, Texas A&M University

Thoughtful instructors tend to consider what their students will, or should, know upon entry into their classes when developing content for their college or university courses. In reality, students often begin courses with widely varied backgrounds of preparation levels for physics content, reasoning, and math skills. To help address these varied backgrounds and enhance student self-learning, a series of supplemental resources were developed to support students beyond the classroom, even when faculty could not be present. Here, we present the results of an analysis gauging the impact of these materials on student outcomes of both conceptual and course assessments in a calculus-based introductory electromagnetism course targeted towards engineering and physical science majors. We will discuss the impacts of these materials using metrics related to students and their prior-preparation, as well as student demographics.

C06-02 (2:12 to 2:24 PM Monday) | Contributed Talk | An Example of Responsive Teaching in University Physics

Presenting Author: Jon Owen, Seattle Pacific University

Additional Author | Lisa M Goodhew, Seattle Pacific University

Additional Author | Brynna Hansen, Seattle Pacific University

Conceptual resources theory proposes that teaching should elicit, refine, and connect student ideas. One teaching practice aligned with this theory is responsive teaching, where instructors seek to understand and pursue the substance of students' thinking while foregrounding connections to disciplinary understandings. Education research literature suggests that responsive teaching has particular learning benefits (e.g., promoting student agency and engagement in authentic scientific practices), yet is also difficult to implement in fast-paced university-level science courses. This may be one reason there are few concrete examples of responsive teaching at the university level. In this talk, we discuss an example of responsive teaching from a small group conversation about heat and temperature in an introductory, calculus-based physics course. In this example, an instructor proposes a thought experiment that takes up and advances students' thinking about heat and temperature. We argue that this case illustrates that responsive teaching is possible in university-level courses with rigorous content learning goals, and exemplifies one way instructors can bridge between students' own thinking and sophisticated content learning goals in a college context.

C06-03 (2:24 to 2:36 PM Monday) | Contributed Talk | Structure, Feedback and Real-World Connections can foster better learning for all

Presenting Author: Richard Gelderman, Western Kentucky University

Barely into the first class meeting it is clear the student is not prepared for the material. From experience, this student will not only do poorly on a assessments but will suck up time and energy with excuses for late and incomplete assignments and will most probably infect fellow learners with a bad attitude. But, what if this did not have to be true? What if every student in your course could succeed? The introductory physics sequence is a gateway course for those desiring a career in science, technology, engineering, and mathematics. Yet the course structure most often offered by institutions of higher education is built upon and magnifies educational inequities and ends up being a barrier for marginalized students. We share a examples from a few of the evidence-based elements incorporated into in our course design and implementation: kick-off with an introductory assignment to model process of science such that every student feels included, and provide structured assessments and feedback.

C06-04 (2:36 to 2:48 PM Monday) | Reducing Marginalization in Physics Classrooms: How to Have Difficult Conversations

Presenting Author: Praisy Poluan

Co-presenting Author | Robert Krakehl

Marginalization in the classroom contributes to a lowered sense of physics identity, thus discouraging the pursuit of physics. To create an environment for maximum student learning, physics educators must present a platform for open dialogue. But having conversations about equity and inclusion is challenging! In this talk, we will inform and prepare practitioners on how to have difficult conversations in their classrooms. Tools and resources such as STEP UP's Guidelines for Conduct During Discussion will be presented, along with other examples and recommendations for creating cultural change.

C06-05 (2:48 to 3:00 PM Monday) | Contributed Talk | Using Grade Monitoring Scheme to Reduce Chronic Absenteeism among Minority Physics Students

Presenting Author: Philomena Agu, Barbara Jordan Career Center

After students returned face-to-face from virtual learning during the pandemic, chronic absenteeism increased in my physics class. These excessive absences impacted their grades. A statistically significant negative correlation, $r = -.73$, $\alpha = 0.05$, existed between their grades and their absences in the 2022 Fall semester, and absences explained 58 percent total variance in their grades. However, they care about passing after missing many school days but fail to understand the relationship between grades and attendance. For example, Andy missed 61 days of school Fall and asked three weeks before the semester ended, "Is there anything I can do to pass this class". They all came to school to take their final exam. Leveraging their care for grades, we developed an attendance and grade monitoring protocol in the 2023 Spring semester. First, students plot graphs of grades and attendance data and interpret the meaning of the negative slope. Second, they fill out of Form about their grades and absences each Monday and write reflections about the relationship between grades and attendance. Completing the form made students more aware of their grades and absences. Though analysis is still in progress, most students reported Form completion positively influences their attendance.

Session C07: Teaching about How Science is Done I & II

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** Mariel Meier

C07-01 (2:00 to 2:24 PM Monday) | | Bridging the Disconnect Between the Classroom Lab and the Research Lab

Presenting Author: Ashley Carter, Amherst College

If you ask an undergraduate at my institution, did your physics lab courses prepare you for work in a research lab, the answer is a resounding no. What is the disconnect? Why can't we train students for research science? I recently taught a sophomore/junior level laboratory to three of my research students and saw first hand that my efforts in the classroom lab did not translate. One issue is that the nature of the science that we do in the classroom laboratory is fundamentally different from the nature of the science in the research lab. In this paper, I describe these fundamental differences--which surround steps for i) how to start a lab project, ii) how to take data, iii) how to collaborate with other scientists, and iv) how to communicate data--and give suggestions for updates to make the classroom lab experience more authentic.

C07-02 (2:24 to 2:48 PM Monday) | | Engaging Over 1400 Students in Authentic Research through an Introductory Course-based Undergraduate Research Experience

Presenting Author: Heather Lewandowski, University of Colorado

Participation in undergraduate research experiences (UREs) has been identified as an important way of increasing undergraduate retention, interest, and identity within the sciences. Course-based undergraduate research experiences (CUREs) have been shown to have similar outcomes to UREs, but can reach a larger number of students at one time and are accessible to any student simply through enrollment in a course. One key component of a CURE is that students must participate in authentic scientific discovery in which they answer a question where the answer is initially unknown to both students and the scientific community. Here, we present student experiences with authentic research in the first large-enrollment, introductory physics CURE conducted remotely during the COVID-19 pandemic. The outcomes of this CURE include a new result suggesting the mechanism for why the sun's corona is so much hotter than the surface of the sun, which is a longstanding puzzle in solar physics. Additionally, we find that the course helped students gain research skills and programing confidence, engage in productive and enjoyable teamwork experiences, and feel motivated and interested in experimental physics research.

Session C08: Calling TYCs: Contributed talks by Two-Year College Faculty

Location: Ballroom A09 **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 2–3 p.m.
Date: Monday, July 17, 2023 **Presider:** Glenda Denicolo

C08-01 (2:00 to 2:12 Monday) | Contributed Talk | Investigating Total Time-to-Degree through Higher Education for Michigan State University Transfer Students

Presenting Author: Alyssa Waterson, Michigan State University

Additional Author | Susan Richter, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Time-to-degree is a temporal representation of graduation often measured at a single institution. Transfer students, however, have attended one or more institutions prior to their final destination, introducing a total time-to-degree in higher education. In this presentation, we investigate how institutional data at Michigan State University measures transfer students' total time-to-degree in higher education. To do this, we will compare how transfer students differ in this measurement than First-Time-In-Any-College students and look into how bringing in different amounts of credits changes the story for transfer students. We explore data through various descriptive statistics results, particularly representing the average time-to-degree in higher education and making comparisons between different populations of students. Preliminary results show that many transfer students have greater than the four-year higher education expectation of time-to-degree and transfer students with more credit (i.e. higher academic level on entry) take much longer to graduate with a Bachelor's degree. We will discuss how these results may influence transfer students' financial, social, and academic approach to their education upon entry to their destination institution.

C08-02 (2:12 to 2:24 PM Monday) | Contributed Talk | Building a Strong Community in Physics and Astronomy Clubs at Two-Year Colleges

Presenting Author: Kayla Stephens, Society of Physics Students

There are many reasons why students choose to attend a Two-Year College (TYC)— it may be smaller class sizes, financial benefits, or transfer agreements. How often do we see students applying for TYCs because of the student groups or clubs and the impact they make in the community? The Society of Physics Students (SPS) believes that the health and strength of physics and astronomy clubs can truly impact the trajectory of their career in the field. This presentation will provide tools and resources to build a strong community within physics and astronomy clubs at TYCs.

Session C09: Workshop: Active Learning Strategies from the Biomedically Relevant

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** TBA

1. Share project goals designed to address faculty and student needs in providing free, editable, biomedically relevant, active learning curriculum for pre-health students and the faculty teaching this population.
2. Interact in small groups as "students" to experience biomedically relevant grant-developed curriculum: Active-Learning Text, Learning Activities, Biomedical Expert Videos, Assessment Questions.
3. Discuss pedagogical application and curricular content
4. Share ideas on adapting curriculum to address student and faculty needs.
5. Explore various forms of curriculum implementation to fit multiple educational environments.

Pre-registration required

Session C10: Physics with Smartphones

Location: Ballroom A11 **Sponsor:** Committee on Apparatus **Time:** 2–3 p.m. **Date:** Monday, July 17, 2023 **Presider:** David Rakestraw

C10-01 (2:00 to 2:24 PM Monday) | | Physics with Smartphones at Fresno State

Presenting Author: In Kim, California State University, Fresno

Additional Author | David J Rakestraw, Lawrence Livermore National Laboratory

Additional Author | Douglas Singleton, California State University, Fresno

Additional Author | Frederick Ringwald, California State University, Fresno

Additional Author | Roger Key, California State University, Fresno

Additional Author | Joseph White, California State University, Fresno

Modern smartphones have sensors that can precisely measure various physical quantities. We can access these sensors to conduct experiments as part of laboratory activities for a standard introductory physics course. At Fresno State, we have incorporated two of these experiments designed to help students understand the physics of motion. In this presentation, I will discuss the merits of these activities, the challenges of implementing them into our curriculum, and future directions.

C10-02 (2:24 to 2:48 PM Monday) | | Improving Engagement and Understanding Using Smart Phone Sensors in the High School Physics Classroom

Presenting Author: Susan Johnston, Livermore High School

A four year ongoing integration of smart phone sensors within the high school physics classroom will be discussed. This integration has occurred at three levels: a 9th grade "Physics First" conceptual physics course, a traditional College Prep Course, and a calculus based Advanced Placement Physics course. Successes and failures of using the sensors within these courses will be discussed including developing teacher expertise, introducing spreadsheets to analyze real world day, and appropriate activities to get students started and quickly gain proficiency with the phone sensors to record and interpret data. In particular, a laboratory experiment developed to improve the understanding of moment of inertia using the cell phone as a torsional pendulum will be explained.

Session C11: Data Science in the Undergraduate Physics Curriculum

Location: Meeting Room 02 **Sponsor:** Committee on Contemporary Physics **Time:** 2–3 p.m.
Date: Monday, July 17, 2023 **Presider:** Deborah Roudebush

C11-01 (2:00 to 2:24 PM Monday) | | Python Programming in the High School Physics and Engineering Classroom for Data, Math, and Simulation Analysis

Presenting Author: Michael Plucinski, QuarkNET and Providence Academy, Plymouth MN

Exposure to computer programming at the high school level can help set students up for success in their future undergraduate and graduate coursework, as well as their careers. However, it can be difficult for schools and students to fit dedicated computer programming or data science courses in their full schedules. Hear how I've integrated Python programming within the Physics and Engineering courses I teach. From use of Jupyter Notebooks for data and math analysis to vPython for simulation work, students are exposed to programming within their planned coursework, helping to set them up for success and confidence with these topics in their future.

C11-02 (2:24 to 2:48 PM Monday) | | Data Science Education Community of Practice (DSECOP): An Approach to Data Science in Undergrad Physics

Presenting Author: Alexis Knaub, AAPT

Additional Author | William Ratcliff, NIST

Additional Author | Marilena Longobardi, University of Basel

Additional Author | Wolfgang Losert, University of Maryland

Additional Author | Mohammad Soltanieh-ha, Boston University

Additional Author | Anil Zenginolu, University of Maryland

The Data Science Education Community of Practice (DSECOP), funded by the American Physical Society (APS) Innovation Funded, began in fall 2021 as a means to make data science part of the undergraduate physics curriculum. Recognizing the need to support physics faculty in teaching data science as an important tool for physicists, this project provides multiple pathways to engage with physics faculty looking to include data science in their physics courses. This presentation provides an overview of the webinars, DSECOP workshops, and modules developed by physics graduate student and postdoc DSECOP Fellows.

Session C12: Panel: Networking and Other Benefits to Mutual Mentoring

Location: Meeting Room 03 **Sponsor:** AAPT **Time:** 2–3 p.m.
Date: Monday, July 17, 2023 **Presider:** Kris Lui

Horizontal or mutual mentoring involves small groups (4-5 people) who are both mentors and mentees at different times. With regular interactions, a mutual mentoring group creates a safe space for individuals to voice concerns, receive constructive feedback, and build a sense of community. Further, mutual mentoring groups expand one's professional network. In this panel discussion, we present benefits accrued during the 5-year e-Alliance Mutual Mentoring Plan D project, other forms of horizontal mentoring groups, and plans to broaden the initiative to all members of AAPT.

Session C13: TYC Short Workshop: LaTeX Is Not Difficult to Learn, and You and Your Students Should Use It!

Location: Meeting Room 09 **Sponsor:** Committee on Physics in Two-Year Colleges **Time:** 2:30–4 p.m.
Date: Monday, July 17, 2023 **Presider:** Joe Heafner

LaTeX has a notorious reputation for being difficult to learn and use, and for this reason is avoided by many people despite being a de facto standard for mathematical content since its invention in the late 1970s. According to LaTeX developers, academics are ironically among the worst offenders when it comes to using LaTeX incorrectly. The resulting frustration causes a negative feedback loop that amplifies perceived difficulties. This workshop is designed to show participants how to set up a proper LaTeX workflow using modern tools and how to create a simple, introductory document with the most common features. The emphasis is on preparing to bring LaTeX into your classroom. Participants should have created a free account on Overleaf (https://linkprotect.cudasvc.com/url?a=https%3a%2f%2fwww.overleaf.com%2f&c=E,1,nZa8dMy2mwWI4wXAPsspKDcyMv2_63qnR9e2mV3hd58Dn6i8bSp3Frx9qbrurSJqitBkes3JKRFR8_bHPnKZ1anTK19NwyyAxAsC5lnpa_Q,&typo=1) and should have a laptop computer or tablet.

Session C14: Visualization in a Planetarium

Location: Exhibit Hall A **Sponsor:** Committee on Space Science and Astronomy **Time:** 2–3 p.m.
Date: Monday, July 17, 2023 **Presider:** Karrie Berglund

This session will be held in the Digitalis Portable Dome in the Exhibit Hall. It will be limited to 20 participants, first come-first seated. Audience members will be seated on the floor. How does an immersive, three-dimensional space such as a digital planetarium help people understand data and make connections? In this interactive session, we will explore three primary types of data visualization in the dome:

1. Exploring the Sky in Multiple Wavelengths: How and why do astronomers use radio waves, infrared light, gamma rays, and more to learn about the sky?

2. Ecology and Habitats: We'll look at different types of habitats on Earth, discuss types of native flora and fauna, and use datasets to explore conditions such as annual rainfall in each habitat.

3. Exploring Galaxies: Unlike stars, galaxies have shapes and structures that can be studied visually. Digital planetaria are able to incorporate actual multiwavelength observations of galaxies, to allow students to use the visual morphologies of galaxies to better understand how they change over time. Because so many have never been able to observe the Milky Way stretching across the night sky, the planetarium dome may be the first time a learner has the opportunity to understand how its appearance allowed us to deduce what it looks like even though we have never been outside its structure. It has only been one hundred years since humans grasped that these "spiral nebulosities" are actually gravitationally bound collections of hundreds of billions of stars that lie far, far away from our own galaxy.

Richard Gelderman.

Session D02: 21st Century Physics in the Classroom

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Jim Rantschler

D02-01 (3:00 to 3:12 PM Monday) | Contributed Talk | Modern Physics Modules

Presenting Author: Gabriel Spalding, Illinois Wesleyan University

We will share our experience with writing assignments that promote interest exploration, which are integrated into a Modern Physics course that utilizes low-cost and no-cost modules: https://sun.iwu.edu/~gspaldin/207L.html#Schedule including hands-on instructional labs, and video-based exercises (https://sun.iwu.edu/~gspaldin/SinglePhotonVideos.html).

D02-02 (3:12 to 3:24 PM Monday) | Contributed Talk | Assessing the Use of Large Language Models for a Project in Quantum Mechanics

Presenting Author: Miguel Rodriguez, California University

Large Language Models (LLMs), such as ChatGPT, are currently shifting the paradigm of the goals and structure of education. Since resisting inevitable technologies is futile, educators and scholars should focus on how to implement and study the effects of this groundbreaking technology, as it is already publicly available. The data in this study comes from a quantum mechanics 2 course, where students used ChatGPT to do their semester project. The project involved them giving me their conversations with AI, on a topic they choose. Then they were tasked with re-wording it, adding diagrams or pictures, and formatting the paper into the final paper and presentation. They were also asked to reflect on their project and the use of ChatGPT. The goal of this study is to (a) report the implementation of ChatGPT and similar technologies in an upper divisional physics course and (b) gather feedback of student experiences to learn how they may have benefited from using such technologies. We hope this study will benefit educators and contribute to the assessment of using LLMs and artificial intelligence in education.

D02-03 (3:24 to 3:36 PM Monday) | Contributed Talk | Bringing Quantum Computing Education to Middle Tennesse

Presenting Author: Hanna Terletska, Middle Tennessee State University

Recently, we have piloted a new "Introduction to Quantum Computing" course for all STEM majors at Middle Tennessee State University. The course does not require any previous knowledge of physics, or advanced mathematics. The course uses a diversity of representations, including the visual representation of quantum qubits and gates before mathematical analysis is involved. We have found that students from all science backgrounds are very curious about learning quantum. We have also developed a set of active learning activities "learning by doing" that students find more effective than a classical lecture. This course will be also adapted for high school students' summer camp and high school teachers' workshops.

D02-04 (3:36 to 3:48 PM Monday) | Contributed Talk | Development of Self-Efficacy in Upper-Division Physics Labs

Presenting Author: Catherine Herne, SUNY New Paltz

In this study we examine the ways in which an upper-division physics lab impacts a student's self-efficacy. Self-efficacy is a person's belief in their ability to perform a certain task; this has been studied in in the context of the introductory physics course and introductory physics lab. The intermediate and advanced physics lab offers a new arena in which to investigate development of student self-efficacy, particularly around scientific thinking and reasoning. We conducted post-course interviews and evaluated student responses. A student's confidence in their degree of scientific thinking increased with student investment in the lab experience or outcomes. Examples of investment included building a foundational knowledge of the experiment before coming to lab, designing an appropriate procedure with a group for efficient data acquisition, and completing a final project that would be shared with classmates. We finish with suggestions for enhancing student self-efficacy in the upper-division lab.

D02-05 (3:48 to 4:00 PM Monday) | Contributed Talk | Particle Physics Playground: Data and Python Tools for your Classroom!

Presenting Author: Matthew Bellis, Siena College

Since 2014, a group of students and I have developed and maintainted a website we call the Particle Physics Playground. It serves up simplified datasets from a number of particle physics experiments, including the CMS experiment at the Large Hadron Collider. Sample python code is provided through Jupyter (python) notebooks hosted on Google's Colab environment, enabling students to access these data with nothing but a Chrombook. Suggested exercises are provided that are appropriate for either an introductory python programming course or an undergraduate course in modern physics or nuclear and particle physics. The current status of the website will be presented and suggestions will be solicited from the audience as to what they would like to see in terms of future datasets or additional exercises. This material is based upon work supported by the National Science Foundation under Grant No. PHY-1913923.

Session D03: Effective Practices for Developing Scientific Thinking, Reasoning and Decision-Making Abilities in Labs

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Stephen Irons

D03-01 (3:00 to 3:12 PM Monday) Contributed Talk | Students Develop and Test Models in Combined Lecture/Lab Setting with Next-Gen PET Curriculum

Presenting Author: Ginger Bryngelson, Francis Marion University

In a combined lecture and lab setting, we've used the Next-Gen PET (Next Generation Physical Science and Everyday Thinking) curriculum with education majors. As they begin each new topic, students discuss their initial ideas, make predictions, and do experiments. They build a (theoretical) model to explain their observations. Students continue to experiment and refine their model with new information and peer review in the form of presenting those ideas to their classmates, answering questions, seeing other students' models, and participating in class discussions to arrive at a class consensus. Eventually, student models converge to match the scientific models taught in textbooks. Thus, students not only learn the concepts we want them to, but also participate in a process that closely mirrors that of actual scientists developing new scientific understanding. The role of the instructor in this setting tends to be one of guiding students through experiments, asking questions of student models, and leading and mediating class discussions.

D03-02 (3:12 to 3:24 PM Monday) Contributed Talk | Revitalizing the Laboratory Curriculum in Major and Non-Major Courses

Presenting Author: Meaghan Ward, University of Waterloo

Additional Author | Urja Nandivada , University of Waterloo

Additional Author | Karen Cummings, University of Waterloo

In this talk I will discuss efforts to update the undergraduate laboratory curriculum at a large research-intensive university, with a focus on first year courses. At this institution we offer first year labs for both majors and non-majors. The revision is motivated by disappointing levels of student satisfaction in traditionally structured labs and by a desire to show students the fun, beauty, and excitement of experimental physics. In both streams, we have introduced new labs based on the philosophy of SQILabs. These labs focus on using data to develop, test and refine models and often involve iterative experimentation, requiring students to make decisions regarding planning and carrying out an experiment. The changes made to the curriculum, as well as the differences between the two streams will be summarized, and shifts in student attitudes and changes in critical thinking as measured on the E-CLASS and PLIC, respectively, will be discussed.

D03-03 (3:24 to 3:36 PM Monday) Contributed Talk | Development of Students' Scientific Abilities in ISLE Courses at Rutgers - Newark

Presenting Author: Patrick Makowski, Rutgers University - Newark

Additional Author | Akwei Bortey, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Joshua Rutberg, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

An essential element of the ISLE approach is students' development of scientific abilities. In this talk we describe how we assess students' scientific abilities in weekly lab write-ups. The same nine abilities for observation experiments and testing experiments are assessed each week. We present student work demonstrating different levels of proficiency and share overall trends in the development of these abilities over the course of a semester. Students' performance worsened as instructor support was weaned, but scores began to improve by the sixth lab. Students were more successful in some abilities than others. A shortcoming of this study is the instructor and context dependence of students' performance in these abilities. We propose different methods of assessment.

D03-04 (3:36 to 3:48 PM Monday) Contributed Talk | Self-Guided Instruction of Uncertainty Analysis in Introductory Labs

Presenting Author: Changgong Zhou, Lawrence Technological University

In our latest round of lab curriculum development, we plan to add an uncertainty analysis module, with the ultimate goal of helping students develop the skill of rejecting outliner data points based on Chauvenet's criterion. Faced with two issues that our students have different mathematics background, and that lab time is already tight, we decide to provide students self-guided tutorials to study outside classroom, instead of lecturing in class. All experiment activities have been modified, and lab assessment has been restructured to support the self-guided learning. This presentation will discuss the implementation of the project with sample lab manual and students' work; the project outcome will also be presented.

D03-05 (3:48 to 4:00 PM Monday) Contributed Talk | Experimental Skills Tests for Undergraduate Introductory Physics Lab

Presenting Author: Caitlin Hansen, Yale University

As undergraduate physics lab curricula shift away from confirmation of physical theory or 'verification' style labs to focus more heavily on the development of experimental skills, it is challenging to appropriately and fairly assess student learning of these skills. We have incorporated a series of short 'experimental skills tests' into our introductory lab curriculum in which students carry out timed investigations that target specific skills like quantifying uncertainties, building mathematical models, designing experiments, and parameter estimations. We will detail specific examples of our experimental skills tests, discuss overall student performance, and consider future improvements.

Session D04: PER: Building a Community of Practice

Location: Ballroom A05 **Sponsor:** Committee on Research in Physics Education **Time:** 3–4 p.m.
Date: Monday, July 17, 2023 **Presider:** Kelby Hahn

D04-01 (3:00 to 3:12 PM Monday) | Contributed Talk | IPaSS: Responsive Professional Development and Building of a Community of Practice

Presenting Author: Morten Lundsgaard, University of Illinois at Urbana-Champaign

Additional Author | Hamideh Talafian, University of Illinois at Urbana-Champaign

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

Additional Author | Devyn Shafer, University of Illinois at Urbana-Champaign

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

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

In this presentation we discuss how the Responsive Professional Development (RPD) approach taken in the Illinois Physics and Secondary Schools (IPaSS) Partnership Program supports building a Community of Practice among high school physics teachers. Rather than training teachers to employ a particular curriculum or pedagogy, this responsive approach aims to support teachers in dealing with their local challenges and implementing new pedagogical approaches aligned with their instructional goals. The IPaSS program includes two weeks of intensive in-person meetings and bi-weekly online meetings throughout the school year. This approach aims to support a Community of Practice in which sharing teaching strategies, curriculum material, feedback to teaching ideas, and moral support is a trademark. In this presentation, we use interviews of teachers and observations from the professional development meetings to show how the responsive nature of the IPaSS Partnership Program supports the development of a Community of Practice among participating teachers.
This work was supported in part by the NSF DRL 20-10188.

D04-02 (3:12 to 3:24 PM Monday) | Contributed Talk | Barriers to Implementing Open-ended Labs with iOLab among High School Physics Teachers

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

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

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

Reform-based laboratory instructions in science that have been associated with investigation-style or open-ended labs have been shown to be effective in enhancing authentic science learning experiences for students. These labs provide ample opportunities for students to act as agentic individuals, making experimental decisions to solve scientific problems and emulating the work of a professional scientist. Despite the acknowledged importance of such labs by many teachers, implementing open-ended labs in high-school physics classes has proven to be challenging, primarily due to structural issues (e.g., time and access to lab materials) and instructional support. In this study, we examined the perceptions of 21 physics teachers regarding the use of open-ended labs in their classrooms using surveys and videos. These teachers were given access to iOLab, a multi-sensor device for performing labs, and instructional support from a physics teaching community of practice through a partnership program. Our analysis identified three significant barriers to implementing open-ended labs in physics classrooms. In addition, we will present inspiring success stories of three teachers who overcame these barriers.

D04-03 (3:24 to 3:36 PM Monday) | Contributed Talk | Whiteboard Speed-Dating in Physics Teacher Professional Development

Presenting Author: Maggie Mahmood, University of Illinois Urbana-Champaign

Additional Author | Devyn Shafer, University of Illinois Urbana-Champaign

Additional Author | Hamideh Talafian, University of Illinois Urbana-Champaign

Out-of-field high school physics teachers, who are often saddled with multiple course preps, must find time and resources to learn and practice the very physics they are asked to teach, often all on their own. Physics Teaching Communities of Practice that bring together physics teachers from different schools are one effective support for out-of-field physics teachers. This talk is situated in a PTCoP that brings together high school physics teachers with a wide range of experience to participate in sustained, high-quality professional development (PD). Nearly half of these teachers are out-of-field. Given the diversity of PD needs arising from the makeup of the group, facilitators must consider what types of group activities would foster a safe and comfortable space for new or out-of-field teachers to strengthen their content knowledge for teaching physics, while simultaneously allowing more experienced physics teachers the creative space to grow. Through video analysis of teacher interactions, teacher surveys, and interviews, this talk illuminates a science teacher PD facilitation technique that is valuable and rewarding for its exposure of teachers to a new pedagogy, and for its ability to engage heterogeneous groups of teachers in comfortable and safe physics content reasoning conversations: Whiteboard Speed Dating.

D04-04 (3:36 to 3:48 PM Monday) | Contributed Talk | Analysis of Secondary Students' Epistemic Framing During Contemporary Physics Instruction

Presenting Author: Zac Patterson, The Ohio State University

Additional Author | Lin Ding, The Ohio State University

Conceptual approaches to contemporary physics topics pose many learning challenges. One factor influencing knowledge integration is a student's epistemological framing. Epistemic frames provide a context within which a particular situation is perceived, interpreted, and judged. The utility of an epistemic frame is context dependent, and the objective of this study is to explore secondary students' framings during introductory instruction on quantum physics. Inductive thematic analysis is used to identify epistemic framing clusters. The characteristics of each framing cluster are identified, and each framing is analyzed based on its sensemaking utility within the observed introductory instructional unit exploring the principles of quantum physics. Data collection includes pre- and post-unit interviews with a student focus group (n=6) as well as student work samples and audio/video recordings of classroom instruction. Evidence of student framings are identified via the warrants students use in their reasoning and the epistemic resources they employ during sensemaking. Three framing clusters emerged from the data; 1) Call on Authority, 2) Experiential, and 3) Evidence-based Sensemaking. Each framing is observed to assist in the student sensemaking process, however, the Evidence-based Sensemaking framing is most effective during the knowledge generation of abstract concepts associated with quantum physics.

D04-05 (3:48 to 4:00 PM Monday) | Contributed Talk | Applying a Volunteerism Framework to Alumni's Informal Physics Experiences

Presenting Author: Bryan Stanley, Michigan State University

Additional Author | Kathleen Hinko, Michigan State University

Many of the physics faculty, staff, and students who facilitate informal physics programs do so voluntarily. University students make up a substantial percentage of the volunteers who facilitate these programs. We have found that volunteers are central to programs' functionality and interactions with audiences. Understanding what volunteers found positive or negative about their experiences can help program leaders think about how they can change and evolve the design and operations of their programs to be more inclusive and equitable. For our qualitative research study, we interviewed alumni about their past experiences as university student volunteers in informal physics programs. We apply a volunteerism framework to understand alumni's goals, motivations, and impacts from their past volunteering experiences as university students. Participants in our study include alumni who no longer volunteer, those who volunteer occasionally in addition to their regular jobs, and some who pursue careers as informal physics program leaders.

Session D05: PER: Active Engagement

Location: Ballroom A06 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Constance Doty

D05-01 (9:00 to 9:12 AM Monday) | Contributed Talk | Examining Professors' Choices while Implementing the Next Gen PET Curriculum through Revealed Causal Mapping

Presenting Author: Julia Willison, University of Central Florida

Additional Author | Erin M Scanlon, University of Connecticut - Avery Point

Additional Author | Jacquelyn J Chini, University of Central Florida

Next Generation Physical Science and Everyday Thinking (Next Gen PET) is a research-based, active-learning physical science curriculum for general education physics courses, with a specific focus on pre-service and in-service elementary school teachers. During pre-COVID introduction of this curricula at various institutions of higher education across the country, instructors implementing this curriculum were recruited to participate in multi-year faculty online learning communities (FOLCs). In this project, we analyze transcriptions of the recorded FOLC meetings through Revealed Causal Mapping (RCM), a qualitative technique to create decision trees from causal statements in text. This method allows us to examine instructors' decision-making while implementing the Next Gen PET curriculum. Here, we share insights about how instructors decide to form groups, including group composition and frequency of group changes.

D05-02 (9:12 to 9:24 PM Monday) | Contributed Talk | Physics Graduate Teaching Assistant Use of Error Framing in the Classroom

Presenting Author: Daniel Sharkey, University of Central Florida Department of Physics

Additional Author | Constance M Doty, University of Central Florida Department of Physics

Additional Author | Erin K H Saitta, University of Central Florida Department of Chemistry

Additional Author | Tong Wan, University of Central Florida Department of Florida

Additional Author | Jacquelyn J Chini, University of Central Florida Department of Physics

Active learning strategies have been shown to support student learning in classrooms and labs. Notably some active learning strategies, such as cold calling, have been shown to increase student anxiety through fear of negative evaluation. Error framing is a pedagogical strategy proposed to mediate fear of negative evaluation. In error framing, instructors frame errors as being a natural and/or beneficial part of the learning process. In previous work, we investigated how graduate teaching assistants (GTAs) operationalized error framing during their training in a mixed-reality simulator and how undergraduate students reacted to example error framing statements. Here, we extend this work to investigate GTAs' use of error framing in their classrooms. We analyzed the error framing statements made by GTAs during observations that followed their training sessions. We explored how these real-life error framing statements compared to the themes identified in our previous analysis in how the statement identified error (i.e., implicit or explicit) and how the error was framed (i.e., natural, beneficial, or positive acknowledgment). Additionally, we also explore how the statements enacted qualities students in prior research identified as positive or negative. Together, these analyses offer insight on what error framing looks like in the classroom.

D05-03 (9:36 to 9:48 AM Monday) | Contributed Talk | Which Basic STEM Skills do Students Choose to Practice?

Presenting Author: Idris Malik, The Ohio State University

Additional Author | Andrew Heckler, The Ohio State University

Online Practice through the "STEM Fluency" application and framework is designed to improve student accuracy and speed (fluency) in basic STEM skills. STEM Fluency can also allow students to choose which skill categories to practice. We observe trends of student category selection in a 2nd-year Intermediate Mechanics course, in the SP21, AU21, and SP22 semesters at The Ohio State University, a large public research university in the Midwest. We examine the effects of the following on students' choice of practice categories in the last assignment: students' previous accuracy and speed on each category in prior assignments, student perspectives on the difficulty and importance of each category, student performance in the course, and students' demographic identities. We use Logistic Regression models to predict student choice and see which factors are most influential. We see stronger signals of 'nonproductive' category selection, namely, students choosing categories in which they are already accurate and fast, in the SP21 and SP22 semesters compared to AU21. We longitudinally track student choice trends across the 2021-22 academic year and report on significant correlations between changes in category selection behavior and grade outcomes. We also discuss a controlled intervention meant to encourage more 'productive' selection of practice categories.
This material is based upon work supported by the National Science Foundation under DUE IUSE Grant No. 1914709

Session D07: Teaching about How Science is Done I & II

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Mariel Meier

D07-01 (3:00 to 3:24 PM Monday) | | A Holistic Approach to Engage Students in Authentic Scientific Pratices in the Physics Classroom

Presenting Author: Yuhfen Lin, California state University, Chico

Co-presenting Author | David T. Brookes, California State University

We will introduce a holistic approach to engaging students in the authentic practices of science; the Investigative Science Learning Environment (ISLE). In the ISLE approach students learn to think like scientists, thereby gaining a deeper understand of and appreciation for the strengths and limitations of scientific reasoning. Their understanding of the nature of science is reflected in gains on attitudinal tests such as the CLASS as well as qualitative data that reveals their ability to articulate how truth is established by practicing scientists. ISLE is not a curriculum, it is an approach to thinking about every aspect of the classroom including the design of the physical space, the way we assess students, student motivation and metacognition, as well as integrating experimentation and development of physical theories into a coherent activity sequence. We will focus on three aspects of implementation: 1. The necessary shift in mindset for both the instructors and for students. 2. The organizational shift in how the classroom is used, and 3. How we have designed innovative ways of assessing students' abilities to engage in scientific practices. In addition, we will discuss some of the successes and challenges we've faced implementing the ISLE approach at Chico State.

D07-02 (3:24 to 3:48 PM Monday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Exploring a Physics Phenomenon through the Practices of Science

Presenting Author: Jessica Watts, Knowles Teacher Initative

Co-presenting Author | Laura Shafer, Knowles Teacher Initative

The nature of science is understood through the lens of the science practices which scientists use to generate knowledge and an understanding of the physical world around us. Students gain insight into the nature of science by engaging with these science practices themselves. When teachers intentionally structure learning experiences such that students engage in these practices while exploring a phenomenon they begin to construct understandings of the underlying physics principles which are the targets of instruction. In this course, adapted from our popular Knowles Teacher Initiative Academy short course, participants will explore a phenomenon chosen to develop an understanding of how the science practices of questioning, modeling, and data analysis support students in building physics content knowledge. Together, participants will consider places in their curriculum where the phenomena and science practices can support their own students in physics knowledge construction. Teachers who attend this course will develop indicators of students' engagement in these science practices; expand their understanding of how science practices support students in building knowledge which is the target of instruction; and explore those "teacher moves" that instructors might deploy to make these practices accessible for all students.

Session D08: Fostering Cooperative Team Environments

Location: Ballroom A09 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Angella Johnson

D08-01 (3:00 to 3:12 PM Monday) | Contributed Talk | Labs Are Fun: Redesigning the Advanced Instructional Lab to Bring Joy to Students and Instructors

Presenting Author: Sara Mueller, Brown University

The instructional laboratory can be a formative environment for growing scientists. Too often the logistical and time constraints of performing physics experiments in a semester coerces instructors to engage in inauthentic forms of experimental science (e.g. prescriptive step-by-step instructions for collecting and analyzing data from 'streamlined' setups). In this talk, I will describe how I redesigned an upper division laboratory course to increase flexibility and reinforce authentic practices in experimental physics. Students in this course were expected to keep a comprehensive laboratory notebook instead of a polished set of reports. They presented their progress as a short slide deck in a 'group meeting' style meeting weekly, seeking and providing advice from their peers and instructors. In the end, an unexpected success of this flexibility led a team of students to develop a new laboratory activity. Students report high levels of satisfaction with this approach, however challenges in writing to communicate their results remain.

D08-02 (3:12 to 3:24 PM Monday) | Contributed Talk | A Longitudinal Approach to Center Communication about Group Dynamics In Physics and Engineering Laboratory and Design Classes

Presenting Author: Katie Ansell, University of Illinois Urbana-Champaign

Additional Author | Rebecca Reck, University of Illinois Urbana-Champaign

Additional Author | Jessica TerBush, University of Illinois Urbana-Champaign

Additional Author | Holly Golecki, University of Illinois Urbana-Champaign

Additional Author | Christopher Schmitz, University of Illinois Urbana-Champaign

Additional Author | Joe Bradley, University of Illinois Urbana-Champaign

Students have ideas about what it looks like to work in a healthy group but are not always well-equipped to establish or maintain healthy group dynamics. In laboratory and design-based courses, where assignments are typically more open-ended and interdependent, emergent unhealthy group dynamics lead to issues like inequitable division of labor and marginalization of some students. Strategies like pre-assigned groups mitigate these issues with mixed results. We propose that instructors may augment preventative strategies with a longitudinal approach that trains students to establish, maintain, and repair group dynamics by explicitly discussing these dynamics. Our multidisciplinary team has designed goal setting and reflective classroom activities that we have implemented in four laboratory and design courses ranging from the introductory level to senior capstone. We are learning that reflective activities promote student-student discussion to realign group function and provide channels of communication for instructors to identify and repair emerging problems. This talk focuses on the considerations for designing and implementing these interventions and the ways instructors can glean information and respond to the reflection assignments so that other instructors may get a sense of how such a longitudinal, training-focused approach to group dynamics may be used in their own laboratory classes.

D08-03 (4:24 to 4:36 PM Monday) | Contributed Talk | Group Activities to Synthesize Understanding

Presenting Author: Matthew Olmstead, King's College

Over the years, I have included different modern board games and activities to help students better understand physics. I have implemented a variety of word games, multiple games involving pictures, and other games involving social deduction. While my focus has been on physics, many of the concepts are not physics specific, but instead focus on connecting concepts and ideas in different ways and looking at them from a different context. I have found greatest success when using short, easy to explain activities in which everyone is doing something, and not putting an individual as the focus. In this talk, I will discuss specific examples of using games/activities, with a focus on the students' favorite games implemented in recent years, how to use them while remote, and on what the students found useful about these activities.

Session D09: Workshop: Active Learning Strategies from the Biomedically Relevant

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** TBA

1. Share project goals designed to address faculty and student needs in providing free, editable, biomedically relevant, active learning curriculum for pre-health students and the faculty teaching this population.
2. Interact in small groups as "students" to experience biomedically relevant grant-developed curriculum: Active-Learning Text, Learning Activities, Biomedical Expert Videos, Assessment Questions.
3. Discuss pedagogical application and curricular content
4. Share ideas on adapting curriculum to address student and faculty needs.
5. Explore various forms of curriculum implementation to fit multiple educational environments

Pre-Registration is Required.

Session D10: PIRA Session – 3D Printed Apparatus for Intro Labs

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Paul Nord

D10-01 (3:00 to 3:24 PM Monday) | | 3D Printing Accessories to Supplement Your Lab Equipment

Presenting Author: Paul Fratiello, Eckerd College

3D printing will not solve all your problems, but it can be a fast and cost effective means to create accessories to supplement your existing lab equipment. Do you need to mount something to a ringstand? Small items can be designed and quickly printed overnight. Do you have equiment from one company that you want to incorporate into another company's lab equipment? Design and print your own adapters. How critical is the accuracy/precision necessary for the lab? You might me able to print something "good enough" instead of purchasing expensive components. In this presentation I will show examples of various parts and adapters that we have used in introductory labs over the years. Some examples: Taking a low cost fan cart and adapting it for use on a dynamics cart; Dynamics cart/track adapters for easy mounting of force probes; Pendulum clamp repurposing items you probably have lying around the stockroom; Laser pointer/optical component holders.

D10-02 (3:24 to 3:48 PM Monday) | | Precision Part Manufacturing from Resin Printing to Mold Making

Presenting Author: Paul Noel, Yale University

Fused filament 3D printing can be great for producing durable parts for the lab but isn't the most precise manufacturing technique. Resin printers can offer an order of magnitude better resolution but are less durable. These tradeoffs and resin printing techniques will be discussed along with methods to compensate for these flaws through mold making.

D10-03 (3:00 to 4:00 PM Monday) 3d Printed Apparatus for Intro Labs

Presenting Author: Benjamin Andersen, California State University, Fresno

3d printers have been in the sub $500 range for close to a decade, making them very accessible and transforming the maker space significantly. The latest generation of 3d printers brings in much more casual users and gives us, technicians who build demos, a tremendous opportunity to customize builds for much less time and money. This talk goes over the basics of FDM (Fused Deposition Modeling) printing, 3d modeling and how 3d printing can be used to enhance intro level labs, from the perspective of an instructional support technician in the Earth and Environmental Sciences department from California State University, Fresno.

Session D11: Data Science in the Undergraduate Curriculum

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Deborah Roudebush

D11-01 (3:00 to 3:12 PM Monday) | Contributed Talk | Detecting Global Warming Using Real Data in a Computational Physics Class

Presenting Author: David Syphers, Eastern Washington University

Exposing introductory computational students to simple data sets can be pedagogically helpful at the beginning, but we also need to expose them to real data sets, with all their complications. Hourly weather station data is often available from NOAA dating back many decades, allowing instructors to get custom data for a particular location. Such temperature records allow students to practice model fitting data with multiple periodicities (diurnal and annual), but it can also show the underlying signal of global warming. I give an example from my introductory computational physics course, where students learn multiple methods for detecting a significant average temperature increase. I discuss pitfalls, including missing or irregular data, and show example Python code that scaffolds the experience for students.

D11-03 (3:24 to 3:36 PM Monday) | Contributed Talk | Teaching Computational Physics in Introductory Courses

Presenting Author: Blane Baker, William Jewell College

Development of students' skills in computation is vital for their careers as professional and hidden physicists. In response, we have begun to incorporate simple programming and graphing into our introductory physics courses. Our approach is to teach students several basic commands, along with the logic associated with computer coding. After this introduction, students engage in several projects that emphasize integrating basic functions to compute quantities such as work, generating arrays to determine position and velocity versus time, and finding rms and other values (without the need for formal calculus). With this preparation, students are competent to continue their studies in computer science courses and/or apply their knowledge in more advanced physics courses. This talk will discuss strategies for teaching computer coding in physics, show examples of projects for students, and suggest other possible problems.

D11-04 (3:36 to 3:48 PM) | Contributed Talk (12 Minutes) | Representational Differences in How Students Compare Measurements

Presenting Author: Gayle Geschwind, University of Colorado, Boulder

Additional Author | Michael Vignal, University of Colorado, Boulder

Additional Author | H.J. Lewandowski, University of Colorado, Boulder

Measurement uncertainty - an essential concept in introductory physics labs - plays a critical role in ensuring the accuracy and reliability of experimental results. An assessment tool called the Survey of Physics Reasoning on Uncertainty Concepts in Experiments (SPRUCE) aims to evaluate students' ability to handle a variety of concepts related to measurement uncertainty. This assessment includes two isomorphic questions, one presented numerically and the other pictorially, with diagrams illustrating error bars and means. Interestingly, despite the questions being identical, students answer them in different ways, indicating that they rely on distinct modes of representation to make sense of measurement uncertainty and comparisons. Unfortunately, even though instructors emphasize the importance of understanding measurement comparison, students frequently struggle with these questions. Notably, students score much higher on the pictorially represented item, showing a gap in ability to compare numerical measurements.

Session D12: 10 Years of PERCoGS: What's Next?

Location: Meeting Room 03 **Sponsor:** Committee on Research in Physics Education **Time:** 3–4 p.m.
Date: Monday, July 17, 2023 **Presider:** Astra Sword

Are you a PER graduate student? Did you know there is a PER student society to support you? It's been 10 years since the founding of the PER Consortium of Graduate Students (PERCoGS). Learn about the history of PERCoGS, what we are doing now, and help us shape the next 10 years! program will be different every time, since the audience input and directives will be different every time.

Session D14: Interaction in Action: The Benefits of Interactive Planetarium Programs

Location: Exhibit Hall A **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Monday, July 17, 2023 **Presider:** Karrie Berglund

A truly interactive planetarium program will be different every time, since the audience input and directives will be different every time. Letting the audience steer the planetarium program affects learning and audience engagement. Join us for a highly interactive planetarium program to find out for yourself.

Alan Gould - Lawrence Hall of Science

PLENARY: Anna Quider

Anna Quider

The US federal government touches all aspects of our lives through its $7 trillion annual budget, laws, regulations, rules, and policies. Physics, astronomy, and education are no exception. Decisions are made from the White House and Congress down to individual program managers that shape what research gets done, how research is done, and who gets to do it. This talk will introduce federal science policy by examining the current federal science funding and policy landscape and exploring its impact on the fields of physics & astronomy and higher education. Dr. Anna Quider will also discuss her experience as a physicist-turned-policymaker working within the federal government at the U.S. House of Representatives and U.S. Department of State, and external to the federal government as a higher education and science advocate.

Dr. Anna Quider brings over 15 years of experience and award-winning leadership spanning higher education, the federal government, and the nonprofit sector to helping clients define and achieve their strategic goals. As a former professional astrophysicist, Anna unites a systems-thinking, analytical approach with enthusiasm and creativity to support clients in co-creating unique solutions to their challenges and driving measurable results. She adeptly guides clients through complex issues and ambiguity, with particular strengths across the science, technology, innovation, and higher education sectors; federal government processes and engagement; program and process optimization; and stakeholder engagement. Diversity, equity, and inclusion are Anna's foundational values and she utilizes a DEI lens for her engagements.

AAPT PHYSICS EDUCATION®

Monday, July 17

4:30–5:30 p.m.

Ballroom A01

Session E01: Education Research in K-12, Part I

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Marta Stoeckel

E01-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | Electromagnetic Spectrum Lesson for Middle and High School Teachers

Presenting Author: Monica Owens, Spectrum X and NRAO

Are you looking for new ways to connect your electromagnetic spectrum lessons to real world applications? Are you looking for hands-on activities or lab experiences to get students engaged? Spectrum X partnered with the NRAO (National Radio Astronomy Observatory) to provide training to ten middle and high school teachers to develop a bank of EM spectrum lesson plans to share with other teachers. Lessons are ready made with handouts and resources, lifting the burden off teachers, and engage students in exploring the EM spectrum in the world around them. Each lesson also includes a connection to groups underrepresented in physics, showing students that all voices matter.
https://www.spectrumx.org/spectrumx-partners-with-nrao-to-develop-electromagnetic-spectrum-lessons-for-middle-and-high-school-students/

E01-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | How to Design Your Own Crystal Radio Using Radio Waves?

Presenting Author: Vicky Lieu, Santiago High School (GGUSD)

Teaching waves and need a new lab inquiry activity? Have your students explored and researched how to build their own crystal radio? In this exciting activity students will model how cellular phone interactions are sent and received through radio waves (cell towers) by drawing a wave using a secret coding chart that encodes each letter with its own unique amplitude and wavelength. Students will create their own special secret message and then have a chance to decode their classmate's messages. Students will start researching how a radio sends and receives amplitude modulation (AM) and frequency modulation (FM) signals. With their research they will be able to construct and evaluate how components of a crystal radio relate to a communication system that transmits information using radio waves to carry a signal by designing their own crystal radio and presenting their research via a medium of their choice (presentation, poster or a flier).

E01-03 (9:24 to 9:36 AM Tuesday) | Contributed Talk | Teaching System Science with NASA Heliophysics

Presenting Author: Christina Milotte, NASA HEAT

Additional Author | Carolyn Ng, NASA HEAT

Additional Author | Lani Sasser, NASA HEAT

Heliophysics is the study of our star, the Sun [helio], how it works [physics], and most importantly, how it affects Earth. Everyone has a connection to the Sun! Engaging learners in heliophysics activities can enhance their understanding of basic physical, biological, and earth science concepts, taking an integrative approach to STEM education. The Sun can provide a fun and exciting laboratory for exploring magnetism, gravity, light, energy, and much more! Learning about the Sun and its influence on the solar system can help scientists understand how the universe began, how stars and planets are formed, and how life can exist on Earth. The NASA Heliophysics Education Activation Team (NASA HEAT) has created a Framework for Helophysics Education, rooted in the Next Generation Science Standards (NGSS), to help educators bring heliophysics content into existing STEM curricula. The framework includes a rich database of heliophysics resources, including activities that engage learners of all ages in NASA missions and data.
Bring heliophysics into your K-12 classroom with NASA HEAT.

E01-04 (9:36 to 9:48 AM) | Contributed Talk | A Free, On-line Text for Middle School Earth & Space Science -- Climate Change Focus

Presenting Author: Jeff Bennett, Big Kid Science

In this presentation I will introduce you to a free, online resource for middle school Earth & Space Science, focusing on the chapters devoted to climate science and climate change. You can explore the project for yourself at grade8science.com. The project meets all NGSS standards for MS-ESS, and can be used without the need for any other resources, as it includes discussion, teacher notes, assessments, and much more. Much of the curriculum can also be used at the high school level.

Session E02: 21st Century Astronomy in the Classroom

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Toby Dittrich

E02-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | Exoplanet Light Curve Demonstration

Presenting Author: Adam Lark, Hamilton College

Additional Author | Brad Moser, Plymouth State University

As a primary approaching to finding exoplanets, astronomers measure the light produced by stars and look for a decrease, or "dip," in the light signal. This dip in the signal can be produced by either an exoplanet or a companion star that crosses, or transits, in front of the host star. In the presentation, I will describe an introductory astronomy demonstration that obtains a live light curve using a light source, a light sensor, and a pendulum. This setup highlights the key characteristics of a transit light curve: transit depth, transit duration, and orbital period. It also demonstrates the difference between a transiting exoplanet and a transiting companion star.

E02-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | Promoting Student Inquiry in Introductory Astronomy using WorldWide Telescope

Presenting Author: Aaron Lee, Saint Mary's College of California

Introductory astronomy courses continue to remain popular at the university level, particularly with students satisfying broader education requirements. As many students' terminal science course, these classes may be the last formal opportunity to develop an appreciation for the scientific process. Increasing appreciation and overall scientific literacy requires that students are capable of seeing themselves "doing" science and not viewing the subject as understandable only by a privileged few. Achieving these goals has become ever-more challenging since the onset of the COVID-19 pandemic, which has brought to light that accessible and engaging laboratory activities utilizing real astronomical data are wanting. I describe three lab activities that use the freely-available WorldWide Telescope (WWT) software. WWT offers a planetarium on a web browser, incorporating astronomical images across the electromagnetic spectrum as well as a 3D model of the Solar System. Students use WorldWide Telescope to perform real scientific experiments by asking questions, collecting data, and reaching evidence-based conclusions on topics related to the electromagnetic spectrum, phases of the Moon, and the retrograde motion of the planets. Students are ultimately responsible for conducting their own investigations and preliminary assessments show students leave with higher confidence in their own ability to understand science-related topics.
Worldwide Telescope: worldwidetelescope.org

E02-03 (9:24 to 9:36 AM Tuesday) | Contributed Talk | Tools for Using Smartphones in the Astronomy Classroom

Presenting Author: Kevin Lee, University of Nebraska

Additional Author | Christopher M. Siedell, University of Nebraska

This presentation will illustrate examples of both simulations and formative assessment tasks targeted at student smartphones in the introductory astronomy classroom. Simulations allow users to configure and switch between multiple representations and contain embedded questions that can be easily assigned to students. The formative assessment tools include both ranking and sorting tasks. Examples from astronomy, astrobiology, and the usage of authoring tools will be shown. All materials are publicly available at the University of Nebraska Astronomy Education website at https://astro.unl.edu.

E02-04 (9:36 to 9:48 AM Tuesday) | Contributed Talk | 21st Century Astronomy in the Classroom

Presenting Author: Jillian Bornak, The University of Toledo

We have them for a few hours a week, but who are our students? Join me in going over results of a decade of survey questions to fill in a picture of the current generation of students. Their circumstances are different than the college experiences of their teachers, so I share this data with the hopes of increasing understanding and flexibility along with learning and accountability.

Session E03: Using, Adapting and Contributing to the Living Physics Portal

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** James Vesenka

E03-01 (9:00 to 9:24 AM Tuesday) | | Developing the Introductory Physics Labs for Life Sciences: Living Physics Portal as a Mechanism for Curricular Adaptation

Presenting Author: Jason May, West Virginia University

Additional Author | Claudia De Grandi, University of Utah

Additional Author | Jordan Gerton, University of Utah

Additional Author | Kevin Davenport, University of Utah

Introductory physics lab courses are at the forefront of curricular innovation and pedagogical creativity. However, faculty and instructors often feel overwhelmed by the abundance of curricular ideas and pedagogical interventions available in today's digital academic landscape, making it challenging to create a conclusive reform plan. In this talk, we share our experiences and outcomes from utilizing the Living Physics Portal (LPP) to facilitate our comprehensive reform of the University of Utah's algebra-based introductory physics laboratory sequence. Through iterative curricular design and educational research, our team developed the Introductory Physics Labs for Life Sciences (IPL2S), an IPLS-designed lab course sequence that emphasizes student engagement in research-aligned experimental practices, interdisciplinary concepts via biological phenomena, and sensemaking about physical mechanisms in biological systems. We describe our process of adapting curricular materials from LPP (e.g., Project NEXUS) and other communities (e.g., NGSS) to align with our student population, course requirements, and institutional resources. Our talk showcases how LPP, its editorial team, and its contribution process can serve as valuable resources for curricular reform in introductory physics labs; it also provides insights into our experiences and outcomes with the IPL2S reform, along with suggestions for how community members can integrate LPP into new curricular initiatives.

E03-02 (9:24 to 9:48 AM Tuesday) | | Bridging Physics and Life Sciences Education: Biologically Relevant Physics Resources in the Living Physics Portal

Presenting Author: Melissa Vigil, Marquette University Department of Physics

The Living Physics Portal is both a resource library and a supportive community for those teaching physics to students with majors in the life sciences. The available materials vary from individual clicker questions and homework problems to lab activities and full curriculums for courses beyond introductory physics. This talk will present an overview of the work currently available in the Portal collection for those looking for ways to include biologically relevant material in their courses. I will also discuss the process by which community members can submit their own contributions highlighting several projects currently in development from rotational motion in lacrosse faceoff play to thermal regulation in bees.

Session E04: PER into Inclusivity and Accommodations

Location: Ballroom A05 **Sponsor:** Committee on Research in Physics Education **Time:** 9–10 a.m.
Date: Tuesday, July 18, 2023 **Presider:** Bradley Ambrose

E04-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | Planning for Participants' Varying Needs and Abilities in Qualitative Research

Presenting Author: Daryl McPadden

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Erin Scanlon, University of Connecticut

Additional Author | Jacquelyn J Chini, University of Central Florida

Additional Author | Harsna Chahal, Michigan State University

Additional Author | Regan Levy, Michigan State University

All people vary in their needs and abilities; however, typical research practices do not consider these variations, which likely impacts who participates in research studies. Additionally, few PER studies have even reported disability identity. Combined, this means that PER researchers typically do not seek out the experiences of disabled people and disabled people might not have access to participate in research studies. In this talk, we demonstrate how a research team can use principles from Universal Design for Learning and the Variation Planning Tool to anticipate ability expectations and create flexible options in a qualitative research study. We then demonstrate how different interview structures can impact disabled participants through a case study with three participants. Finally, we conclude with suggestions for researchers in planning their study designs. Through this example, we hope to encourage researchers to examine their own methods and offer alternative formats in their research design.

E04-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | Applying a Three-Dimensional Framework of Disability Models to Postsecondary Physics Education

Presenting Author: Jacquelyn Chini, University of Central Florida

Additional Author | Constance M. Doty, University of Central Florida

Additional Author | Erin M. Scanlon, University of Connecticut, Avery Point

While the term 'disability' is commonly used, its meaning and function vary across place and time. Goldiner proposed a three-dimensional framework to describe how common models of disability relate. In this framework, disability models that contradict each other create axes related to the cause of disability (i.e., social versus medical), the effect of impairment on well-being (i.e., tragedy versus affirmative), and the ability/disability dichotomy (i.e., minority group versus universal). However, an individual's viewpoint or a policy may simultaneously express models from multiple axes without contradiction, creating "clusters" of disability models. Here, we interrogate practices from the extant literature on teaching postsecondary physics with disabled learners to uncover the common disability models and model clusters underpinning postsecondary physics education.

E04-03 (9:24 to 9:36 AM Tuesday) | Contributed Talk | Physics Instructor Perspective of Students Who Need Flexible Instructional Strategies

Presenting Author: Constance Doty, University of Central Florida

Additional Author | Camille Coffie, University of Central Florida

Additional Author | Daniel Oleynik, University of Central Florida

Additional Author | Erin Scanlon, University of Connecticut

Additional Author | Jacquelyn J Chini, University of Central Florida

When teaching a postsecondary physics course, instructors might consider making accommodations with specific groups of people in mind. In such instances, an instructor might make an instructional change for the whole class or individual students. The Inclusive Teaching Strategies Inventory (ITSI) was developed to explore faculty beliefs about the importance of 13 accommodations and/or inclusive teaching strategies as well as their self-reported use of those strategies. In pilot testing with physics instructors, we added a prompt about who instructors are considering when implementing these strategies. We distributed the ITSI to instructors at Two-Year Colleges and through the APS listserv during Spring 2020, and received 80 complete survey responses. For some strategies, participants selected "Students Who Need It" for whom they would do the accommodation. Participants responded to an open prompt about who they include in this category. Here, we share common themes of who instructors might consider when they think of "Students Who Need It". We draw on our findings for implications about designing a physics course.

E04-04 (9:36 to 9:48 AM Tuesday) | Contributed Talk) | A PER-based Physics Course on Removing Barriers to Inclusivity in STEM

Presenting Author: Mario Belloni, Davidson College

Co-presenting Author | Julia Berlin Schneider, Davidson College

In the Spring of 2019, the Physics Department at Davidson College transformed its introductory course series with support from an HHMI Inclusive Excellence grant. All our introductory courses now use a studio-based, "experiment-first" approach, which allows these courses to be more diverse, equitable, and inclusive. Despite this, our introductory physics gateway courses have remained primarily about the teaching and learning of physics. In the spring of 2022, we created a course, PHY 101, which explicitly focuses on understanding and remedying historical and present-day barriers to inclusivity in physics and astronomy, and STEM more broadly. This course attempts to address two challenges: in many courses, deep investigations of diversity, equity, and inclusivity often come at the expense of content, and diversity, equity, and inclusivity are often considered the sole domain of the humanities and social science. PHY 101 applies the discipline-based techniques of physics and astronomy education research, thereby using content within our own discipline to explore and remove the barriers to diversity, equity, and inclusion in physics and astronomy. In this talk, we will discuss how this approach has worked, describe a few student projects, and explore the effect of this course on Davidson and Davidson's physics curriculum.

Session E05: PER into Reasoning in UG Physics

Location: Ballroom A06 **Sponsor:** Committee on Research in Physics Education **Time:** 9–10 a.m.
Date: Tuesday, July 18, 2023 **Presider:** John Elwood

E05-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | Motivational and Performance Consequences of Over-estimating Exam Performance

Presenting Author: Eric Burkholder, Auburn University

A well-known finding from popular psychology is the Dunning-Kruger effect – the tendency of low-performers to overestimate their own performance. In much of the literature on this effect, it is taken as a given that more accurate self-assessments of performance are crucial for not just the success of individuals, but for the success of industries like healthcare. Yet, we have not found a study that directly measured differences in outcomes that were correlated with inaccurately estimating one's performance. Here, we investigate changes in physics knowledge and physics motivational beliefs that are correlated with overestimating one's performance on physics exams. We find that students who overestimate their exam performance do not see any gains in physics knowledge over the course of a semester, compared with a 0.30 standard deviation increase for students who do not overestimate. We also find that students who overestimate their performance see increases in test anxiety, increased interest in physics, and increased stereotype threat. In sum, the results suggest that an inability to accurately assess one's own performance may have negative impacts on both learning and motivational beliefs in physics.

E05-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | Using the Cognitive Reflection Test in Physics Education Research

Presenting Author: Paula Heron, University of Washington

Additional Author | Kristin Kellar, University of Washington

Additional Author | Drew Rosen, University of Maine

Solving a physics problem often requires a sustained effort involving recalling concepts, performing calculations, sketching figures, weighing alternative approaches, etc. But sometimes, an answer springs to mind without our even being conscious of reasoning – the answer just appears. According to dual-process theories of reasoning, these represent two distinct types of cognitive processing: Type 2 is slow, deliberate and effortful; Type 1, fast, automatic, and effortless. Type 2 processing is engaged when reflection on the output of Type 1 processing finds it unsatisfactory. The Cognitive Reflection Test (CRT) is widely used for assessing the propensity for such reflection.[1] The CRT is increasingly being used as a means to detect Type 1 reasoning in physics instructional contexts. The general idea is that students with stronger cognitive reflection skills are likely to be more successful on questions that elicit strong intuitive but incorrect responses. In order to make use of the

CRT we need to separate the effects of cognitive reflection from those of general cognitive ability or physics background. Data collected in introductory courses at several institutions will be used to examine how scores correlate with final course grades and to examine how familiarity with the test affects outcomes.
[1] Frederick, S. (2005). Cognitive Reflection and Decision Making. In Source: *The Journal of Economic Perspectives* (Vol. 19). Supported in part by DUE 1821123

E05-03 (9:24 to 9:36 AM Tuesday) | Contributed Talk | Helping Students Develop Validity-checking Skills

Presenting Author: Safana Ismael, North Dakota State University

Additional Author | Mila Kryjevskaia, North Dakota State University

Recent research shows that even those students who demonstrate that they possess formal knowledge tend not to use it productively, especially on questions that elicit intuitively appealing ideas. Dual-process theories of reasoning suggest that to catch a mistake, a reasoner must recognize reasoning red flags, consider alternatives, and check for the validity of a most plausible response. To help students apply relevant knowledge to check for validity, we designed a sequence of longitudinal interventions in the context of Newton's Second law. Throughout the semester, students were presented with tasks that tend to elicit strong intuitive (but often incorrect) ideas. The students then were prompted to apply Newton's Second law to check for the validity of their initial responses. Results suggest that intuitive ideas have a strong hold on the students and are not easily dislodged even through repeated practice applying Newton's Second law to evaluate their validity. We will discuss implications for instruction.
This material is based on work supported by the National Science Foundation under Grant Nos. DUE-1431940, DUE-1431541, DUE-1431857, DUE-1432052, DUE-1432765, DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, DUE-1821561

E05-04 (9:36 to 9:48 AM Tuesday) | Contributed Talk | Photovoice in an Upper-Division Physics Capstone Project

Presenting Author: Kristin Oliver, University of Colorado Boulder

Additional Author | Victoria Borish, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Additional Author | Heather J Lewandowski , University of Colorado Boulder

Photovoice is a type of participatory action research that aims to enable people to act as agents of change. Using a camera, participants take photos in response to open-ended prompts and write a short caption to accompany their photos. At the end of the photovoice process, participants engage in a focus group where they collectively determine some themes that their photos show, allowing them to co-create the research being done. We implemented the photovoice methodology in a project-based physics course in which the students partnered with a quantum company to work on a real-world project. We present here an example of how photovoice can be used in a physics course with a focus on some results from the focus group. These results demonstrate that the focus group allowed us to gain new types of information that we may not otherwise have learned, and that the students appreciated the photovoice process.

E05-05 (9:48 to 10:00 AM Tuesday) | Contributed Talk | To Teach or Not to Teach, that is the Question

Presenting Author: Qing Ryan, California State Polytechnic University-Pomona(CPP) - Pomona, CA

Co-presenting Author | Jie Yang, East China Normal University, Shanghai, CHINA

Additional Author | ShiYu Gao, East China Normal University, Shanghai, CHINA

Additional Author | XiJia Guo, East China Normal University, Shanghai, CHINA

In order to investigate whether there are any differences between students who choose to become high school teachers versus those who do not, we conducted a survey in the Department of Physics at East China Normal University. East China Normal University offer teaching trajectory for undergraduates in physics department. Students on the teaching trajectory are pre-service teachers who are going to be middle school physics teachers after graduation. 266 undergraduate students responded to the questionnaire, and there are about equal number of men and women as well as who are on the teaching and non-teaching trajectory. Students' self-efficacy and physics identity were compared between the teaching and non-teaching trajectory. Possible gender gaps were also evaluated in these measures. Male and female students' self-reported motivation in choosing the physics major and the teaching career were also compared for students on the teaching and non-teaching trajectory. In this talk, I will discuss the findings and talk about possible implications of the study.

Session E06: Being a Student-Ready Physics Classroom

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Raeghan Graessle

E06-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | We Are All in this Together: The Opportunities and Challenges of Group Assessment Courses

Presenting Author: Jean-Francois Van Huele, Brigham Young University

Physics courses are intended to provide students with tools allowing them to achieve the learning outcomes and prepare them for the future. Course assessments have both a formative role of encouraging mental preparedness and creating learning moments and a summative role of quality control and evaluation of the course and course participants, students and instructors. Current practices in physics research and professional settings are increasingly collaborative. How does the pedagogy respond? In many cases by allowing and encouraging collaboration between course participants..Can we go further and enforce collaboration through group assessments? In this talk I report on my experiences with group assessments in introductory, intermediate, and advanced physics classes of varying sizes and I attempt to gauge what success means in terms of technical skills, motivation, engagement, and equity.

E06-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | Course Modifications to Move Towards Universal Design for Learning

Presenting Author: Kristen Burson, Grinnell College

Additional Author | Melissa Eblen-Zayas, Carleton College

Additional Author | Danielle McDermott, Los Alamos National Laboratory

The Universal Design for Learning (UDL) framework can support instructors in designing courses that reduce barriers to learning for all students. The framework, developed by Center for Applied Special Technology [1], provides a set of research-based guiding principles and specific checkpoints that serve as a guide for devel-

oping classrooms that are more accessible. A recent study by Scanlon et al. examined the alignment of research-based physics curricula with the UDL checkpoints and concluded that these curricula were unaligned with many of the checkpoints, especially in terms of providing multiple means of engagement [2]. Here we present three concrete course modifications that physics instructors can use to move towards UDL, focusing on the UDL guiding principle of multiple forms of engagement. In particular, we present techniques to (1) design the social aspects of group-work to reduce student anxiety, (2) to increase mastery-oriented feedback, and (3) to provide students choice for course assignments [3]. References: [1] UDL: The UDL Guidelines. https://udlguidelines.cast.org/. [2] Scanlon, E et al. *Phys. Rev. Phys. Educ. Res*. 14, 020101 (2018). [3] Eblen-Zayas, M. et al. *Phys. Teach.* 60, 628–631 (2022).

E06-03 (9:24 to 9:36 AM Tuesday) | Contributed Talk | PASCO Smart Carts Can Fill Pot Holes for Physics Classes

Presenting Author: Eliza Morris

Additional Author | Brenda Weiss, CSU Sacramento

Additional Author | Mikkel Jensen, CSU Sacramento

In our hands-on lab for calculus-based physics at CSUS, students work with PASCO smart carts to build a robust understanding of the connections between work and kinetic energy. Each module follows the same learning cycle. Students begin with reading and teamwork focused on developing a strong conceptual foundation, followed by lab and an out of class assignment designed to reinforce concepts. At the end of the week the students will complete an in-person assessment and discussion related to the module. The module will conclude with an out of class homework assignment. At the start of the work-kinetic energy module the students will build intuition on the concepts of both work and kinetic energy through team based guided inquiry learning. The lab, an essential element of the student learning cycle, gives students the opportunity to physically interact with the concepts through the equipment. Students check to see how much kinetic energy is generated by various quantities of work and prove that the amount of work done equals the change in the kinetic energy of their PASCO smart cart. At the end of the learning cycle the students demonstrate their learning through an assessment wrapping up that module.

E06-04 (9:36 to 9:48 AM Tuesday) | Contributed Talk | Interactive Engagement and Remote Learning: A South African Case Study

Presenting Author: Kebra Ward, Massachusetts College of Liberal Arts

Additional Author | Lindsay Westraadt, Nelson Mandela University

Physics education research shows that students learn best while actively engaged with course material, rather than passively observing a lecture. The flipped classroom curriculum and peer instruction are two complementary methods that foster active student engagement. The purpose of this study was to measure the effectiveness of these interactive engagement (IE) approaches within the post-COVID 19 South African physics classroom. In this study, a flipped classroom curriculum combined with peer instruction was implemented in three first-year physics courses at Nelson Mandela University. The success of this combined IE approach was quantitatively measured against international benchmarks using the Force Concept Inventory (FCI) test. The results of this study explore the robustness of an IE approach to teaching and learning against topical challenges, such as online learning and large classes, by studying their impact on FCI performance. Use of the preliminary FCI score as a means for targeting limited college-readiness resources is also explored.
The authors gratefully acknowledge financial support for this research by the Fulbright Scholars Program, which is sponsored by the U.S. Department of State. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Fulbright Program or the Government of the United States.

Session E07: PER & Assessment Ideas III

Location: Ballroom A08 **Sponsor:** Committee on Research in Physics Education **Time:** 9–10 a.m.
Date: Tuesday, July 18, 2023 **Presider:** Jennifer Snyder

E07-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | Cognitive Diagnostic Computerized Adaptive Tests with the LASSO Platform

Presenting Author: Jayson Nissen, Nissen Education Research and Design

Additional Author | Phuong-Vy Le, Iowa State University

Additional Author | Ben Van Dusen, Iowa State University

Additional Author | Xuixui Tang, Purdue University

Additional Author | Yuxiao Zhang, Purdue University

Additional Author | Amirreza Mehrabi, Purdue University

We are creating a new assessment that provides instructors with actionable information about student skills and knowledge central to succeeding in introductory physics courses. This Cognitive Diagnostic Computerized Adaptive Test (CD-CAT) assesses a student's development on learning objectives selected by the instructor. We began by building the CD-CAT on existing data from research-based assessments collected with the LASSO platform. Using item response theory and cognitive diagnostic models, we estimated three-parameter logistic models and item fit statistics to evaluate model fit statistics, evaluate our q-matrix, and estimate DINA model item parameters. The initial results show good item psychometrics and q-matrix fit. This indicates that CD-CAT can provide a reliable and valid measure of learning objectives for introductory mechanics courses. The CD-CAT will be available for instructors to use through the LASSO platform in the Fall of 2023.

E07-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | Analysis of a Hybrid Take-Home / In-Class Examination Technique in the College Physics Classroom

Presenting Author: Paul Stonaha, Lafayette College

Additional Author | Stephanie Douglas, Lafayette College

Traditional in-class summative assessments are high-stress tests used to evaluate student understanding and to provide a grade for students' academic performance. We present the results of a new hybrid take-home / in-class testing approach. In this approach, students are provided the test one week before the formal in-class examination. Each test is substantially harder than a typical in-class examination. We present the results of a survey-based study on students taking 2nd semester calculus-based physics (Electricity and Magnetism). When comparing survey results between the experimental (hybrid style, N=69) and traditional (pure in-class, N=32) testing groups, we find the hybrid test approach reduces student stress while allowing the test to serve better as a learning experience. In this presentation, we review the challenges we faced using the hybrid test approach along with the advantages and disadvantages of this approach for the physics instructor.

E07-03 (9:24 to 9:48 AM Tuesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Constructive Practices for Implementing a Culture of Assessment

Presenting Author: Diego Valente, University of Connecticut

As instructors, we are often looking at assessing our students to measure learning outcomes determined for the courses we are teaching, but how do these outcomes fit with the big picture of the degree program as a whole? Are courses administered in a way to provide students with a cohesive learning experience that helps them develop the skills they need to be successful in their careers after graduating? In this presentation, we will discuss the experience of implementing a culture of assessment in a large public university through a university faculty fellow program, where, instead of a top-down approach from university administration, faculty members work with academic units to support the development of assessment plans for their programs. We will address successes and challenges in such implementation, encouraging discussions among attendees regarding their own experiences and perceptions of what may or may not work in their own institutions. The final goal of this round table discussion will be to provide attendees with ideas for constructive practices that can be utilized in any type of institution.

Session E08: Inclusive Teaching in Labs

Location: Ballroom A09 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Catherine Herne

E08-01 (09:00 to 9:24 AM Tuesday) | | Astronomy for Students with Visual Impairments: The Stem Career Exploration Lab

Presenting Author: Thomas Madura, San Jose State University

Additional Author | Carol Christian, Space Telescope Science Institute

Additional Author | Tiffany Wild, The Ohio State University

Additional Author | David Hurd, Pennsylvania Western University

Additional Author | Lindsay Bartolone

Additional Author | Noreen Grice

The possibility of a future in astronomy, or any science, technology, engineering, and mathematics (STEM) field, seems daunting for students with visual impairments (VI). Three dimensional (3D) printing though may hold promise for students with VI in addressing science content, concept development, and providing access to information normally displayed visually. To bolster astronomy and STEM opportunities for students with VI, we developed the STEM Career Exploration Lab (CEL), which employs tactile astronomy instruction via 3D printing technologies and unique 3D-printed models. In partnership with numerous schools and agencies for the blind, to date we have held eight week-long STEM CEL summer camps in multiple states around the country, serving about eighty students with VI. We gather pre- and post-intervention data via student and teacher surveys, astronomy assessments, and interviews. In this talk I will summarize the STEM CEL approach, describe some of our 3D models and activities, and share what we have learned thus far. Once fully tested and refined, we will make our 3D model files and lessons freely available for further use and study. This work is supported by a generous Innovative Technology Experiences for Students and Teachers (ITEST) grant from the National Science Foundation.

E08-02 (9:24 to 9:48 AM) | | Toward Equitable Peer Recognition in Labs: Implications from Multiple Social Network Analysis Studies

Presenting Author: Meagan Sundstrom, Cornell University

Additional Author | Ashley B. Heim, Cornell University

Additional Author | L. N. Simpfendoerfer, Cornell University

Additional Author | Annie Tan, Cornell University

Additional Author | Barum Park, Cornell University

Additional Author | N. G. Holmes, Cornell University

When students gain recognition from their peers as a physics person, they are more likely to persist in physics. Prior work, however, demonstrates that student recognition of strong physics peers favors men over women and that men report higher perceptions of peer recognition than women in their physics courses. In this talk, I will discuss a series of three studies in which we investigate the relationship between student gender and peer recognition in physics labs in particular and highlight their implications for inclusive lab instruction. These studies draw on methods of social network analysis to determine whether a gender bias in student nominations of strong peers exists in different lab contexts. We also analyze students' explanations of their nominations to understand what skill sets get recognized in peer recognition. Finally, we compare students' perceived recognition to the number of nominations they receive from their peers as strong in their physics lab course. Implications include possibilities for instructional interventions such as discussing the multitude of ways to be a strong physics lab student and how to appropriately internalize recognition from others.
This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program Grant No. DGE-2139899 and Grant No. DUE-1836617.

Session E09: Advances in Introductory Courses I

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Forouzan Faridian

E09-01 (9:00 to 9:12 AM Tuesday) | Contributed Talk | Demographics and Student Success in Introductory Calculus-based Physics at Santa Fe College

Presenting Author: Karim Diff, Santa Fe College

We present an analysis of student data in introductory calculus-based physics courses at Santa Fe college. These courses are often considered to be gateway courses for students in STEM disciplines. Our analysis was conducted to identify possible achievement gaps within our student population in the context of the Santa Fe College Quality Enhancement Plan. This program emphasizes equity-minded teaching strategies to improve academic success for all students. The goal of this analysis is to serve as a baseline to evaluate the success of future departmental initiatives.The data presented is disaggregated by race/ethnicity, gender, and first-time in college status.

E09-02 (9:12 to 9:24 AM Tuesday) | Contributed Talk | A Survey of Conceptual Modern Physics Courses in U.S. Colleges and Universities Intended for First-Year Non-Science Majors

Presenting Author: Annie Courtemanche, Bemidji State University

Co-presenting 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 courses focused on modern physics concepts intended for 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, these courses have 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 have conducted an extensive review of the course catalogs of most major 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 typical 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.

E09-03 (9:24 to 9:36 AM Tuesday) | Contributed Talk | Learning Introductory Physics with Activities: A Multimedia Open-source Textbook Replacement

Presenting Author: Paul Emigh

Additional Author | Rebecka Tumblin, Oregon State University

Traditional textbooks often serve as a foundation for introductory physics courses despite the fact that students do not always learn well from physics textbooks. Such books can also come at considerable cost, which can be a barrier to students' pursuit of STEM degrees. In a flipped classroom setting, we are in the process of transitioning students' pre-class assignments from textbook readings to videos. These videos are then paired with minimalist text resources and student-centered generative activities to promote a more active pre-class experience as students get ready for their in-class work. We discuss the interplay between videos, activities, and text aimed at supporting student learning in the role typically filled by a traditional textbook. The work is being published under a creative commons license so that instructors can adopt or adapt them in a way that best fits their own course.

Session E10: Digital Measurement, IoT, and AI Technology for Sustainable Development

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Andre Bresges

E10-01 (9:00 to 9:24 AM Tuesday) | | Using Arduino-based Irrigation to Teach STEM Subjects in Context of Sustainable Education

Presenting Author: Dietrich Jeschke, Flensburg University of Applied Science

An irrigation project based on the common Arduino platform and cheap available parts can be used to teach STEM subjects for different age groups. The project shown is both simple enough in its architecture that makes it easy to understand and complex enough in its details to go into depth if needed. The project is shown in its parts, with the needed code and circuits. Three examples are shown how to use the project. Example one shows how to teach elementary school children basic engineering and to show them what a computer program and a sensor is and why wiring is necessary. Example two shows how to teach physics to high schoolers. The amount of irrigated water will be measured as well as the throughput of the pumps. Then it can be calculated how much cooling is provided by the plant. Finally example three is used to teach college students how microcontroller interfaces work using self coded drivers. Due to the use case of the project all these lessons are provided in the broader context of sustainability. Similar technology as used in the project is used in actual irrigation systems available on the market.

E10-02 (9:24 to 9:48 AM Tuesday) | | How Might We Raise Interest in Robotics, Coding, Artificial Intelligence, STEAM and Sustainable Development in Education?

Presenting Author: Jannik Henze, University of Cologne, Institute of Physics Education

Additional Author | Andre Bresges, University of Cologne, Institute of Physics Education

Digital Measurement, IoT, and AI technology are emerging fields that have great potential to contribute to the achievement of sustainable development goals in the education sector. These technologies can be utilized in various ways to support the delivery of quality education, enhance learning outcomes, and promote sustainable practices. IoT devices can collect data on temperature, humidity, and air quality, helping schools operate more sustainably. Digital measurement tools can track progress towards education-related sustainable development goals, such as promoting gender equality and enhancing the quality of education. AI technology can provide personalized support to students, answering questions and providing feedback, enhancing the learning experience and helping students achieve their goals. However, ethical considerations must be taken into account when implementing these technologies to avoid further inequalities in the education sector. All students must have access to these technologies, regardless of their socio-economic background or location. This presentation shows how the utilization of digital measurement, IoT, and AI technology in class can contribute to the achievement of sustainable development goals. The implementation was guided by principles of responsibility, transparency, and equity, ensuring that they serve the needs of all learners in a sustainable and inclusive manner.

Henze J, Schatz C, Malik S and Bresges A (2022) How Might We Raise Interest in Robotics, Coding, Artificial Intelligence, STEAM and Sustainable Development in University and On-the-Job Teacher Training? Front. Educ. 7:872637. doi: 10.3389/feduc.2022.872637

Session E11: Building Quantum Information Science and Engineering Curriculum for a Diverse Community of Learners – I

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Todd Zimmermann

E11-01 (9:00 to 9:24 AM Tuesday) | | Kinesthetic Activities for Learning Quantum Mechanics

Presenting Author: Elizabeth Gire, Oregon State University

Additional Author | Corinne A. Manogue, Oregon State University

Additional Author | Kelby T. Hahn, University of Utah

Additional Author | Adam Frye, Oregon State University

In order to help students understand quantum state vectors and modeling quantum measurements, we've invented some kinesthetic classroom activities. In series of activities, students explore complex numbers and complex-valued vectors/spin states using their arms. In these activities, students explore complex arithmetic, orthogonality, relative & overall phase, time-evolution, and wavefunctions. In another activity, the students experience a quantum measurement "skit", the students and instructor enact a measurement process as a probabilistically determined projection and renormalization. I will discuss the affordances of these kinesthetic activities and how we use them to help students grapple with the abstract formalism of quantum mechanics.

E11-02 (9:24 to 9:36 AM Tuesday) | Contributed Talk | Toward a Validated Assessment of Quantum Information Science Concepts

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

Quantum information science (QIS) is an emerging interdisciplinary field at the juncture of physics, computer science, electrical engineering, and mathematics leveraging the laws of quantum physics to circumvent classical limits on information processing with applications including sensing, communication, and computation. Despite interest by researchers in PER and other discipline-based education research communities in developing scalable research-based curricular and assessment materials to promote effective teaching and learning in QIS courses, such efforts have historically been limited by a perceived lack of consensus among educators on core content. Drawing on our team's prior experience identifying core content for a thermodynamics and statistical mechanics assessment, we report findings from a survey of QIS instructors on content coverage in QIS courses at US institutions, with particular attention paid to the implications for our ongoing work developing a scalable QIS assessment. Specifically, we identify a subset of material assessed in 80% or more of courses from which to develop and refine assessment items and present our preliminary work toward developing this assessment which we intend to make available for pilot distribution in Fall 2023.

Session E12: Using Authentic Astronomy Research in the Classroom

Location: Meeting Room 03 **Sponsor:** Committee on Space Science and Astronomy **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023
Presider: TBA

INVITED PANEL
Rachel Freed, Institute for Student Astronomical Research
Elan Lavie, El Cerrito High School
Tommy Morford, El Cerrito High School
Katherine Lee, El Cerrito High School

Astronomy research can require sophisticated equipment, hard-earned telescope time, and copious amounts of money, but networks of remotely operated telescopes can move research from the world of professional astronomers into the hands of aspiring scientists at even the high school level. One place in which this is happening is the Institute for Student Astronomical Research, which has created online communities of teachers and students who are carrying out their own investigations. This panel will include talks from INSTAR President Rachel Freed about the programs and their efficacy as well as from high school teachers and students who have conducted and published astronomy research. There will also be time for questions about the process and how to bring such projects into your own high school or introductory college classroom and the meaning such opportunities have had for students.

Session E13: Make Do Play and Learn Sharathon – Iron Chef Physics

Location: Meeting Room 09 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Frank Lock

Session F01: Education Research in K-12, Part 2

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Marta Stoeckel

F01-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | How Does Switching to an NGSS-based Curriculum Affect Equity in the High School Classroom?

Presenting Author: Jolene Johnson, University of Wisconsin River Falls

Next Generation Science Standards (NGSS) is a set of K-12 science standards developed by states to improve science education for all students. Instead of focusing on rote memorization of scientific facts, NGSS focuses on learning to be a scientist, which is believed to make science more accessible to all students. This talk focuses on how NGSS has been implemented in a low income and high minority student population school. We will discuss how the curriculum was developed and adapted to increase access to science for all students. In addition, we will present preliminary data on how students responded to this new curriculum, including student increase in interest in future physics classes and related majors, who is participating in classroom discussions, and pre/post test data on students' attitudes toward science and their scientific skills.

F01-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Physics of Art and Design: An Introductory Physics Course that Is Accessible and Creative

Presenting Author: Elmarie Mortimer, Trinity Preparatory School

High school physics courses generally receive less student interest compared to other courses. Although overall high school physics enrollment in the U.S. has been stable since the 1990s, some states are experiencing decreases in student enrollment in physics from a lack of student interest. In Florida, enrollment in public high school physics courses have steadily declined since 2014, with a drop of 6.6% reported from Fall 2021 to Fall 2022. The math-heavy nature of typical high school physics courses, which are accessible only to a select group of students with proven abilities in math, may be to blame. To address these issues, we developed an introductory physics course targeting non-traditional students by emphasizing physics concepts that incorporate everyday phenomena and serve as a pathway for subsequent science courses, such as chemistry. The course focused on waves and wave properties, and mastery of each topic was demonstrated through creative design projects rather than traditional mathematically-oriented tests. The Colorado Learning Attitudes Science Survey (CLASS) and the Wave Diagnostic Test (WDT) were administered pre- and post- instruction to measure student aptitudes and attitudes towards physics. We will discuss changes in student learning and potential changes to curriculum to encourage greater engagement.

F01-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | Investigating Longitudinal Impacts of an Informal Physics Program

Presenting Author: Jessica Hoehn, University of Colorado Boulder

Additional Author | Turhan K Carroll, The Ohio State University

Additional Author | Noah D Finkelstein, University of Colorado Boulder

Physics has a strong tradition of informal education and community engagement, including demo shows, public lectures, museum exhibits, afterschool clubs, summer camps, etc. While research studies often document immediate impacts of such informal learning experiences, studies of longitudinal impacts are less common. We are in the process of examining and documenting long-term impacts of one informal physics program that seeks to cultivate interest and support science identity development for marginalized youth through a physics-based afterschool program. Through a mixed methods study, we are documenting the types of impacts this program can have, and is having, on youth participants (e.g., college attendance, science identity, persistence in STEM, among others). In this talk, we present our longitudinal research approach along with preliminary results from surveys and interviews from our first year of data collection. We discuss methodological challenges and lessons learned so far.

Session F02: 21st Century Physics in the Classroom II

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Rudra Kafle

F02-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Simulating Reality: Computational Particle Physics Research with First-Year Undergraduates

Presenting Author: David Clarke, University of Utah

Lattice field theory (LFT) is a highly relevant and successful tool in understanding nucleon structure and the Standard Model. Since it lies at the nexus of several advanced topics in physics, mathematics, and computer science, it is traditionally not encountered until graduate school. On the other hand, it is likely enlightening and motivating for beginning undergraduate students to have some exposure to modern research in theoretical physics. I report here on a semester-long experience guiding four first- and second-year undergraduates through a lattice calculation; in particular, we reproduce through our combined effort the pure gluon deconfinement temperature. Students managed simulations on a computing cluster, wrote Python scripts to perform very basic statistical analysis, gleaned some information from lattice literature and textbooks, and summarized aspects of what they learned in a final report. I attempted to impress on them a non-rigorous, heuristic understanding of how lattice calculations function. This class was carried out in the context of University of Utah's Student Research Initiative.

F02-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Finite Element Simulations of Resonating Blood Clots for a Classical Mechanics Course

Presenting Author: Benjamin Levy, Davidson College

Additional Author | Chenlu Qin, Davidson College

Additional Author | Christopher Piatnichouk, Davidson College

Additional Author | Juan Camilo Pérez Góngora, Davidson College

Additional Author | Griffin Whalen, Davidson College

Driven damped oscillators are important not only in upper-level, undergraduate Classical Mechanics courses, but also in current physics research. To bring recent, exciting medical imaging physics techniques into the classroom and to make a complicated, mathematical topic more tangible, we designed a finite element simulation-based module. The module comprises three activities spread out over three class days. Students first employ a simple simulation to become acquainted with the software and to recover the familiar analytical result for a driven, damped oscillator. They then simulate and visualize the vibrational modes of an "intermediate" example such as a wine glass where analytical treatments are challenging. On the final day they investigate simulations and results from ongoing ultrasound-based medical imaging research in which the vibrational modes of blood clots subject to an external, sinusoidal magnetic driving force may, in the future, be used to make treatment decisions. We believe that by bringing relevant biological and medical physics applications into the classroom we can better engage students who might otherwise be less excited by the theory-heavy course.

F02-03 (10:24 to 10:36 AM Tuesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Simulating the Action Principle in Optics

Presenting Author: Refath Bari, City College of New York

Light has a fascinating property: it always travels the path that takes the least time between any two points. This is the motivating property behind optical phenomena such as reflection and refraction. The unreasonable economic efficiency of light is captured by a single proposition: the principle of least action (PLA) in optics. Unlike reflection and refraction, which emerge from optimizing a one-dimensional function, the PLA emerges from optimizing an infinite-dimensional functional. The PLA can be difficult for students to comprehend, as the formulation of the Lagrangian is often left unexplained. To this end, this paper presents various simulations to demonstrate the action principle, including a numerical solution to a generalization of the brachistochrone problem to an arbitrary refractive profile. The interactive simulations discussed in the paper are available at Ref. 1.
Published in February 2023 edition of *The Physics Teacher*

F02-04 (10:36 to 10:48 AM Tuesday) | Contributed Talk | Teaching a First-Year Course on Critically Evaluating Science in the Media

Presenting Author: Colleen Countryman, Ithaca College

To consume media regarding science, one must critically evaluate their sources and content. I developed a first-year course that investigates the way that society perceives science in the media. The course explored the ethical and cultural implications of scientific communication in the news, on social media, and in the movies. We used critical thinking techniques to analyze the portrayal of complex issues of science from a variety of perspectives, and we aimed to gain a deeper understanding of scientific literacy in the media and the perils of misinformation.
In this talk, I will discuss a few particularly successful group activities in which we leveraged students' individual backgrounds and interdisciplinary expertise to analyze the complex relationship between science and the media.

Session F03: Innovations in the Classroom

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** James Vesenka

F03-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Unconventional Physics: Teaching Temperature by Analogy

Presenting Author: Gerardo Giordano, King's College

One of the most exciting topics that we cover in my Applied Biophysics course for Athletic Training majors is thermodynamics. With sports applications ranging from keeping warm in the winter and cool in the summer to treatments such as thermotherapy and cryotherapy, it is an area that the students recognize as fundamental to their training. And at the heart of thermodynamics is one of the most difficult and necessary topics for students to grasp, temperature. After years of trying multiple avenues to help my students understand this all-important quantity, I finally found a way to bridge the divide between the colloquial misconceptions about temperature that we gather from our daily lives and the intense mathematical rigor needed in an upper-level thermodynamics class. By using a few familiar analogies discussed through group activities, I have measured repeated consistent gains in my students' conceptual understanding of the notion of temperature.

F03-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Designing Our Own Pro Models

Presenting Author: Ritesh Kohale, Sant Gadge Maharaj Mahavidyalaya,Hingna,Dist-Nagpur,MH,India,441110

This presentation intends to design our own pro models for class room teaching again expensive intruments and apparatus. These pro models are very handy ,intellectual and can be constructed from common things in labs and daily life. Some of the pro models we constructed and utilized in classrooms teaching are projected in this study. The pro model of Wilson Cloud chamber,GM COUNTER,X-ray tube,Lissajous figures without CRO,Joule thompson effect,Young laplace equation,ideal gas law are truly working and students wondered in classroom while the interacted. As far as daveloping countries are concerned and where there is issues of financial assistance for purchasing expensive apparatus in schools and colleges such kind of models and practices can be useful for achieving intended learning objectives in classroom teaching. Also students can directly get in the concepts of physics rather than studying theories and histories of science. The further development and cost cutting practices for such kind of models are ongoing.

F03-03 (10:24 to 10:36 AM) | Contributed Talk (12 Minutes) | Effective Physics Instruction in the Online Classroom

Presenting Author: Dustin Hemphill, Penn State Erie - The Behrend College

I have developed introductory calculus based physics classes in the online-asynchronous teaching modality. The courses were designed and developed in collaboration with instructional designers and passed an internal application of the Quality Matters standards for online courses. I will discuss the design of the courses, best-practice features of the courses, how academic integrity is upheld, and effective lab practices in this modality.

Session F04: PER that Helps Investigate Physics Program Effectiveness

Location: Ballroom A05 **Sponsor:** Committee on Research in Physics Education **Time:** 10–11 a.m.
Date: Tuesday, July 18, 2023 **Presider:** Bradley Ambrose

F04-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Characterizing the Impact of Integrating Computation into the Physics Major

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

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

In physics research and development, computation is not just a useful skill - it is an almost universal mode of problem-solving and communication. Physicists use computation to model, simulate, predict, analyze, and present results about physical systems. However, most undergraduate physics majors learn computation as an add-on, not an integral part of their education. The School of Physics and Astronomy at the University – Twin Cities, is beginning a plan to integrate computation into all physics major courses. As part of the integration process, the Physics Education Research group at UMN will investigate how undergraduate students of different identities experience physics major courses before and after they are computationally integrated and measure the impact of the holistically introducing coding on student achievement. The methodological foundations and preliminary results of this mixed-methods case study will be the central focus of this presentation.

F04-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Predicting Upper-level Course Outcomes Using Bayesian Networks

Presenting Author: John Hansen, West Virginia University

Additional Author | John Stewart, West Virginia University

Physics students' success in completing physics programs is highly dependent on how successful they are in their physics courses. Effective advising of students on which physics courses to take and when to take them is a crucial responsibility of physics departments as they strive to increase student success. The identification of which students are at risk of failing a particular course before enrolling in a course would allow departments to make informed decisions as they advise undergraduates. This study used Bayesian networks to visualize the correlations between final grades in introductory physics and mathematics courses and upper- level physics courses and predicted upper-level physics course outcomes based on the identified correlations. Decision threshold tuning was used to maximize the models' effectiveness in predicting both successful and unsuccessful outcomes and, as a result, Bayesian network models proved to be effective in identifying at risk students in upper-level physics courses.

F04-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | Investigating the Assessment Landscape of Physics Graduate Programs

Presenting Author: Bill Bridges, Kansas State University

Additional Author | Caitlin Solis, Kansas State University

Additional Author | Joshua Barron, Kansas State University

Additional Author | Jacquelyn J Chini, University of Central Florida

Additional Author | Rachel Henderson, Michigan State University

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, and we are interested in the variety of ways that physics graduate students' comprehension and progress are evaluated. We conducted a landscape study of university handbooks and websites documenting the ways in which students are assessed throughout their program. This includes practices such as written examinations, the courses required, and the timeline to graduation. These results were compared to determine alignment among universities of the varying practices. We also compared our findings with recommended practices of "Graduate STEM Education for the 21st Century" determined by a committee of the National Academies of Science, Engineering, and Medicine. This work will help to better understand what the numerous institutions across the country consider as necessary practices and requirements for graduate students. Developing this landscape can provide a resource for graduate programs looking to update their practices, and a foundation for further investigations into graduate education within physics programs.

F04-04 (10:36 to 10:48 AM) | Contributed Talk (12 Minutes) | Investigating Academic Burnout in Undergraduate Physics Experiences

Presenting Author: Harshini Sunil, University of Colorado, Boulder

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

The term burnout is being used at increasing rates among physics students. Combined with research linking burnout to negative health and career outcomes, this increase in burnout presents a concern with respect to students' performance and retention. In this research, we will examine the experiences of undergraduate physics students in order to understand how they experience burnout. At the beginning of Fall 2022, we conducted interviews with 7 undergraduates enrolled in upper-division physics or engineering physics classes at two large research universities. We analyzed the data to determine key symptoms that students experienced who self-identified as having feelings of burnout. Following the interview study, we conducted a survey of 24 students to further investigate the symptoms of students that experienced burnout in physics. This paper presents the symptoms of the students who self-identified as burned out. The strategies used by students with lower levels of burnout are also presented.

Session F05: PER into Reasoning in UG Physics

Location: Ballroom A06 **Sponsor:** Committee on Research in Physics Education **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023
Presider: John Elwood

F05-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Students' Thinking in Instructor-Assigned vs Student-Selected Engineering Design Problems

Presenting Author: Ravishankar Chatta Subramaniam, Purdue University

Co-presenting Author | Amir Bralin, Purdue University

Co-presenting Author | Carina M Rebello, Toronto Metropolitan University

Co-presenting Author | Jason W Morphew, Purdue University

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

In a technology driven world,students must understand how science and mathematical concepts apply to real-world problems; brainstorm ideas, iterate, evaluate ideas; reflect on their thinking; and base their statements on scientific principles. Considering the recommendations of reform documents such as NGSS to provide an instructional context to bridge Engineering Design with Science Thinking, we have reformed the laboratory component of a calculus-based course for engineers. We intend to compare the patterns of thinking and reasoning during group discussions in two laboratory-based multi-week ED tasks, one of which was instructor-assigned and the other student-selected. The audio recordings of the discussions within 14 groups of students for which the author was the TA will be transcribed, analyzed and coded. The results of our study will suggest ways to enhance the Design Science connection, in introductory calculus-based physics courses.
Supported in part by U.S National Science Foundation Grant 2021389.

F05-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Topic Analysis of Student Essays in a Physics Course for Engineers

Presenting Author: Amir Bralin, Purdue University

Co-presenting Author | Ravishankar Chatta Subramaniam, Purdue University

Co-presenting Author | Jason W Morphew, Purdue University

Co-presenting Author | Carina M Rebello, Toronto Metropolitan University

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

This study is a topic analysis of student essays written in an introductory physics laboratory. It was conducted at a large American mid-western university, in a physics course with over 2,000 students enrolled annually. The course content centered around three fundamental principles of mechanics: momentum, energy, and angular momentum. The labs constituted one fifth of the total grade. In the last five weeks of the course, students completed a multi-week lab assignment: to write an essay about a real-world problem in mechanics. They were given agency over the type of the problem: as long as it involved one of the listed principles. Given the diversity of student responses, we analyzed the text of 600+ essays using machine learning to find the topics which are common to many of them.
Supported in part by U.S. National Science Foundation Grant 2021389

F05-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | Effects of Homework Collaboration on Course Performance

Presenting Author: Keith Foreman, University of Nebraska-Lincoln

Additional Author | Karl Ahrendsen, Smith College

Working on homework questions with a collaborative partner, or "study buddy," is usually not prohibited by an instructor and is sometimes even openly encouraged.

We aim to quantify the effect of collaborative homework problem solving on student's behavior and final course grade. The large-enrollment introductory physics course studied deploys homework sets online. The online homework website stores an enormous amount of information about student activity and this metadata is ripe for analysis. We focus on the timestamps for homework answer submissions. By correlating the time that answers were submitted for each unique pair of students, a probability can be assigned that a particular pair were study buddies. With the study buddies identified, fast Fourier transforms are used to compare the regularity of homework interaction of study buddies and students working alone. Auto-correlations are also performed on each student's submission time data and the auto-correlation coefficients are correlated to exam scores [1] for both study buddies and solo workers. Our findings indicate no substantial difference in regularity of course access or course grade between study buddies and solo workers.
1. G. Kortermyer, J. Sci. Educ. Technol. 25, 697 (2016)

F05-04 (10:36 to 10:48 AM) | Contributed Talk (12 Minutes) | Data Suggest that Student Reasoning Aligns with Dual Process Theories

Presenting Author: Kristin Kellar, University of Washington

Additional Author | Paula Heron, University of Washington

Dual Process Theories of Reasoning (DPTs) suggest that humans reason using System 1 (heuristic) and System 2 (analytic) thinking processes. When faced with a task, System 1 automatically engages to generate an initial model. System 2 may or may not be engaged to evaluate that model. The provisional model generated by System 1 may be inappropriate, and System 2, if activated, may not successfully override that model. Thus, the reasoner might not arrive at the correct conclusion, even when the necessary content knowledge and skills are available. This phenomenon can explain student inconsistencies in response to similar physics questions. Student responses to sets of related questions that elicit contradictory responses will be discussed, along with scores on the cognitive reflection test (CRT) [1].
[1] Frederick, S., J. Econ. Perspect. 19, 2005. This study is supported by the National Science Foundation under Grant No. DUE 615418.

Session F06: Being a Student-Ready Physics Classroom

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Raeghan Graessle

F06-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Improving Student Success through Active Learning and Peer Leadership

Presenting Author: Mikkel Jensen, California State University, Sacramento

Additional Author | Eliza J. Morris, California State University, Sacramento

Introductory STEM classes can pose significant hurdles to college students, often disproportionately so for groups of traditionally underserved students, such as first-generation students. Several strategies, including using active learning modalities, can improve student success and mitigate the high failure rate. But how do you effectively implement active learning without added cost in very large lecture sections? We developed a model, the Integrated Peer Leadership Program (IPLP), in which students work in hierarchical groups and support each other in an active learning setting. By taking turns serving as peer leaders, students practice leadership skills and elevate both their own learning and that of their peers. Over four semesters, the model reduced the student failure rate, reduced student achievement gaps, and improved student learning gains on formative assessments. We anticipate that the model, which has no additional cost or time needs for instructor or institution, is portable to other large STEM courses.

F06-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Designing a Storyline To Increase Student Engagement In Physics Labs

Presenting Author: Jessica Watts, Knowles Teacher Initiative

Co-presenting Author | Laura Shafer, Knowles Teacher Initiative

At the core of every physics lab is a story that unfolds through students' use of the science practices. Teachers can intentionally leverage storylines interwoven throughout a curriculum sequence to help students connect physics ideas to build an understanding of the natural world. Teachers will develop an understanding of how the connections among phenomena, science practices and physics principles can drive a powerful and engaging learning experience for all students. Teachers will learn about ways to modify existing lesson sequences to build a storyline that better connects the core ideas that are the targets of instruction so as to increase student access to physics. Participants will experience connecting a learning goal to a phenomenon and data and explore indicators of student engagement with the practices.

F06-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | Aligning Ungrading to Your Goals and Values: There's More than One Way to Do It!

Presenting Author: Benjamin Pollard, Worcester Polytechnic Institute

Grading is embedded in many societies' approach to formal education. Yet grading is known to contribute to inequity in education (including physics) by ranking students, gatekeeping, and holding outsized influence on students' careers and livelihoods. Thus, recently, some educators have been turning a critical gaze towards grading and evaluative practices overall. One approach to equitable educational reform is known as ungrading, the practice of de-emphasizing or removing grades altogether in formal classroom settings. Today, "ungrading" serves as an umbrella term encompassing a variety of approaches and structures to feedback and evaluation. A small but growing group of physics instructors have been adopting and adapting these approaches. To better understand the landscape of ungrading practices, and to help support instructors who want to use ungrading, we need to characterize and distinguish different approaches and connect them to the myriad goals and values from which they emerge. In this talk, I outline a preliminary framework for characterizing ungrading practices in higher ed STEM classrooms.

F06-04 (10:36 to 10:48 AM Tuesday) | Contributed Talk | Assessing and Harnessing Student Readiness on the First Day

Presenting Author: Kathleen Harper, Case Western Reserve University

Additional Author | Kurt R. Rhoads, Case Western Reserve University

Students enter college with a wide variety of backgrounds, expectations, motivations, perceptions, and goals. They have varied beliefs and suspicions about their personal preparation for a course. We have recently started our introductory engineering course by giving students three prompts to gain insights into their learning goals, previous experiences, and engineering perceptions. We share a summary a period or two later to springboard into a discussion reiterating course goals and policies and sharing metacognitive strategies. The discussion also helps students feeling underprepared see they are not alone and underscores that all students have things to learn. We can also use the results to tailor certain course aspects. The most common student questions are sent to appropriate experts; the results are posted as a resource on the course management system. We will share implementation details, commonly observed trends, and ideas for adapting it to other courses.

Session F07: Navigating the Faculty Career

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Anne Cox

F07-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Why My Teaching Evaluations Got "Adjusted" Down – And What it Taught Me about My Students

Presenting Author: Richard Zajac, Kansas State University Salina - Aerospace & Technology Campus

Evaluation of teachers by students is common practice. The scores from these evaluations inform decisions about reappointment, promotion and tenure. Given the wide variety of factors that influence these scores, many institutions routinely employ some numerical recipe to adjust these scores even if the exact recipe is poorly understood by the faculty in question. Prompted by a recent adjustment of my own scores that seemed anomalous, I undertook an exploration of the recipe employed at Kansas State University, which includes multiple regression analyses based on years of KSU historical data. What I found paints an insightful landscape or phase space in terms of varying student effort, interest, and students' own perception of their instructor and of their own learning. The mapping out of this "physics of teaching evaluations" suggests certain whimsical strategies for gaming the system and is enlightening for better understanding the motivation behind an institution's use of adjusted scores.

F07-02 (10:12 to 10:24 AM) | Contributed Talk (12 Minutes) | From Tough Love to Lovingkindness — What I've Learned from My Advisees

Presenting Author: David Hammer, Tufts University

I've taught calculus-based introductory physics for several decades, with recent enrollments of 90-100 students. Over the past five years, I've been shifting in my approach, specificaly in how I attend to students' affect, a shift I attribute to what I have learned from a series of PER doctoral student and post-doctoral advisees. I will give a brief overview of the research, concerning entanglements of emotions and engagement physics, especially with respect to feelings of uncertainty (Conlin & Scherr, 2018; Jaber & Hammer, 2016; Radoff, et al, 2018; Phillips, et al, 2017; Watkins, et al, 2018; Appleby, Dini, et al, 2021; Jaber, 2021). My main focus for this presentation, however, will be on various changes I have made in my teaching. These include adjustments to the substance, with added emphases on the value in doing physics of expressing and engaging with confusion; I will give examples from assignments, labs and exams. They also include a deliberate and in some ways more difficult shift in the tone of how I interact with students, which I characterize as a change from "tough love" to "lovingkindness." Time permitting, I will sketch ideas for research on what these changes may have accomplished.

F07-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | The New Faculty Workshop Reimagined: Introducing the Faculty Teaching Institute (FTI)

Presenting Author: Stephanie Chasteen, Chasteen Educational Consulting

Additional Author | Rachel E. Scherr, University of Washington Bothell

Additional Author | Edward Prather, University of Arizona

The Physics and Astronomy New Faculty Workshop (NFW) recently celebrated its' 20th anniversary and has been the go-to professional development experience for new physics and astronomy faculty, with transformational effects. The NFW has continuously evolved over its history, but further changes are necessary to meet the needs of today's instructors – who are increasingly knowledgeable and motivated to use student-centered teaching practices. Thus, an expert team* is creating a research-based redesign of the NFW. Rebranded as the Faculty Teaching Institute (FTI), the workshop redesign is centered around student-centered teaching, reflective teaching practice, equity diversity and inclusion (EDI), and community-building, within the context of a fulfilling academic career. Guided by design principles (such as "we lead with practical advice," and "we explicitly foster choice and agency"), the FTI includes sessions on careers and identity, common general teaching approaches (e.g., lecture, labs, group work), learning "pods," and a written action plan. Post-workshop, participants are able to choose from a menu of support, ranging from reminders to enact the action plan, personalized teaching critiques, Faculty Online Learning Communities, and virtual "free help sessions." See more at http://physport.org/FTI. This talk will share the redesign and results from the inaugural FTI (June 2023).

The FTI is a project supported by the American Association of Physics Teachers, American Physical Society, and American Astronomical Society and the National Science Foundation under Grant Nos. 2141678, 2141745, 2141769, 2141795, and 2142045. The leadership team is listed at https://www.physport.org/fti/About.cfm.

Session F08: Inclusive Teaching in Labs

Location: Ballroom A09 **Sponsor:** Committee on Laboratories **Co-Sponsor:** Committee on Diversity in Physics **Time:** 10–11 a.m.
Date: Tuesday, July 18, 2023 **Presider:** Catherine Herne

F08-01 (10:00 to 10:24 PM Tuesday) | | Group Dynamics in Inquiry-based Labs: Inequities and Interventions

Presenting Author: Andrew Loveridge, University of Texas at Austin

Additional Author | Matthew Dew, Cornell University

Additional Author | Emma Hunt, University of Texas at Austin

Additional Author | Gregorio Ponti, Harvard University

Additional Author | Jonathan Perry, University of Texas at Austin

Additional Author | Viranga Perera , University of Texas at Austin

Recent studies provide evidence that while reducing course structure in accordance with active learning strategies improves learning overall, it can also exacerbate inequalities. In the context of introductory labs, this can mean an increase in inequitable task division, among other problems. This presents instructors with a serious tension: research-based pedagogical methods which are best for overall student learning may be worse for diversity, equity, and inclusion. We report on an ongoing empirical study of this issue in the context of two large introductory physics lab courses at the University of Texas at Austin. Drawing upon a variety of data collection methods – including coded video recordings of students working in lab, pre and post semester surveys, and interviews – and through comparisons with established literature, we attempt to paint a portrait of inequitable group dynamics in inquiry-based labs. We also provide an assessment of two distinct intervention strategies, one based on partner agreement forms and another which encouraged cooperation between different groups. These interventions were designed to improve equity and inclusivity but yielded mixed results. Collectively, our findings have implications for the design of improved or alternative interventions which may be more successful.

F08-02 (10:24 to 10:48 AM Tuesday) | | The Experiences, Perceptions, Beliefs, and Intentions of Physics Majors in Courses that Incorporate an Experimental Lab Activity

Presenting Author: Dana Thomas, North Carolina State University

Additional Author | Laura Clarke, North Carolina State University

In 2013, a faculty member in the Department of Physics at NC State University developed a collection of experimental lab activities to provide undergraduate physics majors and minors with the opportunity to conduct short, inquiry-based experiments in the department's shared research facility as part of their physics courses. Each fall and spring semester since its inception, 3-5 physics courses have incorporated an experimental lab activity as an official course component. For my dissertation, I completed three studies, each focused on discerning factors that influence the experiences, beliefs, perceptions, intentions of undergraduate physics majors who enroll in courses that incorporate an experimental lab activity. The first two studies utilized multilevel modeling to examine the contextual dynamics of students' physics ability beliefs, sense of belonging, disciplinary identity, and persistence intentions over time. The third study employed narrative inquiry to explore the lived experiences and disciplinary identity development of physics students with marginalized or multiple marginalized social identities in the context of the power dynamics of their physics learning environments. This talk shares major findings and implications from the three studies, which together offer insight into how undergraduate physics programs can foster diversity, inclusion, equity, and justice in physics learning spaces

Session F09: Advances in Introductory Courses II

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Forouzan Faridian

F09-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk | Comparing Student Use of Representation of Energy in a Modeling Classroom

Presenting Author: Benjamin Archibeque, Oregon State University

Additional Author | Miguel Fadhel, Florida International University

Additional Author | Zahra Hazari, Florida International University

Additional Author | Geoff Potvin, Florida International University

Students enter university physics with different experiences in physics classrooms. These experiences, or lack thereof, influence their time in a university physics classroom. This work investigates how students' previous experience may be related to the way they engage with new information in a Modeling Instruction classroom. To explore this, we analyzed how two groups of students leveraged three representations of energy (system schemas, energy pie charts, and equations) in a modeling classroom. These representations were introduced to students within two successive class periods. In one group, half of the students had taken a physics course previously and in the other, only one student had taken physics previously. We found that the groups focus on different representations in practice problems, namely the group with less physics classroom experience leveraged the non-equation representations more.

F09-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Considering and Teaching the Values Embedded Energy Concepts

Presenting Author: Kara Gray, Seattle Pacific University

Additional Author | Rachel E Scherr, University of Washington Bothell

Physics has the reputation of being purely about nature, not about people or culture. Energy is usually presented as one of the most abstract and universal topics in science: it appears in every scientific discipline, it cannot be perceived directly, and it is notable mainly for being conserved. However, physics concepts (including energy) are not "out there" in the universe, free of cultural values: rather, they are created and sustained by people in specific times and places, for the purpose of addressing particular social needs and empowering particular people. Teaching about the values embedded in energy concepts allows our students to investigate how their values intersect with those assumed in textbooks or used in physics calculations. Helping students to consider these values can make physics more applicable to students' everyday lives and decisions and inspire them to work on the problems and opportunities they see around them. This talk will include examples of how this can be done in a physics classroom.

F09-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | Adding Self-Regulated Learning Instruction to an Introductory Physics Class

Presenting Author: Danielle Maldonado, West Virginia University

This talk will present the preliminary results of an effort to add explicit self-regulated learning instruction to a college calculus-based introductory physics class. Students received short instructional segments on general self-regulation strategies, the metacognitive and cognitive reasons those strategies were often successful, and specific strategies helpful in the college physics environment. Students were encouraged to reflect on the success of their study methods in preparation for course exams, with four surveys given once monthly throughout the semester. Students rated the effectiveness of their chosen strategies and reported which changes, if any, they intended to make in the future to achieve their academic goals.

Session F10: Augmented and Virtual Reality for Physics Education and Beyond

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Michael Gallis

F10-01 (10:00 to 10:24 AM Tuesday) | | Insights from a Large Controlled Study of Virtual Reality in Physics

Presenting Author: Joseph Smith, Marietta College

Additional Author | Chris Orban, Ohio State University

The BuckeyeVR project utilized the accessibility of smartphone-based Virtual Reality (VR) to perform one of the largest controlled studies of VR in physics education. Through a multi-part study over two semesters, nearly 1,000 students in introductory electromagnetism courses were exposed to traditional and VR treatment types for topics including electric and magnetic field direction and Gauss' Law. We summarize differences in improvement from pre-test to post-tests for different treatment groups and consider gender and previous experience with video games. We also discuss insights from the study including: (1) the importance of training students to use the virtual environments before instruction (2) the need to develop reliable assessments to evaluate 3D physics understanding, and (3) technical challenges that arise from implementing and maintaining smartphone applications for education. These considerations will help guide future efforts to effectively implementing educational virtual/augmented reality experiences for sustained instruction.

F10-02 (10:24 to 10:48 AM Tuesday) | | Learning about Magnetism with Augmented Reality and the MARVLS App

Presenting Author: Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

The MARVLS App is an augmented reality app for students to explore physics models of abstract or 3D concepts. MARVLS is an acronym for manipulable augmented reality visualizations to learn spatially. Topics in the second semester of a first-year physics course were chosen for the app as there are many abstract and 3D concepts that are new to students and can be difficult to understand. 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 STEM fields including physics, engineering, chemistry, and mathematics. In this talk we will present and demonstrate the App, describe the set of in-class activities we use with the app, and present some of our initial results of the student experience using the app.

Session F11: Building Quantum Information Science and Engineering Curriculum for a Diverse Community of Learners – II (modern, quantum and accessibility)

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 10–11 a.m.
Date: Tuesday, July 18, 2023 **Presider:** Todd Zimmermann

F11-01 (10:00 to 10:12 AM Tuesday) | Contributed Talk) | Why Teach Quantum Computing Topics in Quantum Mechanics?

Presenting Author: Gina Passante, California State University, Fullerton

Co-presenting Author | Steven J Pollock, University of Colorado Boulder

Additional Author | Homeyra Sadaghiani, California Polytechnic University, Pomona

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Quantum information science is a fast-growing field that has generated a lot of interest in recent years. We have found undergraduate physics students to be aware of, and motivated by, this field. One way to leverage their natural interest and curiosity is to incorporate topics from quantum computing or quantum cryptography into a traditional quantum mechanics course. Many examples can fit seamlessly into the curriculum as they require very little formalism beyond Dirac notation and ideas about superposition and measurement. This allows for the reinforcement and application of essential principles of quantum mechanics. In this talk we will explore the advantages of including quantum computing examples in your classroom and where, when, and how they could fit into your course(s).

F11-02 (10:12 to 10:24 AM Tuesday) | Contributed Talk | Curricular Materials to Introduce Quantum Computing Examples in Quantum Mechanics Courses

Presenting Author: Steven Pollock, University of Colorado Boulder

Co-presenting Author | Gina Passante, California State University, Fullerton

Additional Author | Homeyra Sadaghiani, California State Polytechnic University-Pomona

Additional Author | Bethany R Wilcox, University of Colorado Boulder

We have designed a set of modular, freely available teaching materials to help instructors incorporate quantum computing examples into their quantum mechanics classes. These materials include instructor guides and do not require faculty to be an expert or sort through the large amounts of materials available online to find something suitable for their course. Our materials include clicker questions, sample lecture notes, tutorials (in class or online), as well as homework and exam questions. The topics include quantum cryptography, basic quantum circuits, tensor products, entanglement and EPR, and quantum teleportation. In this talk we will share several examples and describe our experience using them in our QM courses. Materials are available at https://www.physport.org/curricula/aceqis/.

F11-03 (10:24 to 10:36 AM Tuesday) | Contributed Talk | Clicker Question Sequence on Two-State System Basics and Change of Basis: Virtual and In-Person Implementation

Presenting Author: Peter Hu, University of Pittsburgh

Additional Author | Yangqiuting Li, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Research-validated multiple-choice questions comprise an easy-to-implement instructional tool for scaffolding student learning and providing formative assessment of students' knowledge. We present findings from the implementation of a research-validated multiple-choice question sequence on the basics of two-state quantum systems, including inner products, outer products, translation between Dirac notation and matrix representation in a particular basis, and change of basis. This study was conducted in an advanced undergraduate quantum mechanics course, in both online and in-person learning environments, across three years. Student learning was assessed after traditional lecture-based instruction in relevant concepts, and their performance was compared with that on a similar assessment given after engaging with the multiple-choice question sequence. We analyze, compare, and discuss the trends observed in the three implementations.

F11-04 (10:36 to 10:48 AM Tuesday) | Contributed Talk | Disrupting Competitive Science Culture through Deliberate Instructional Policies and Practices in a Modern Physics Course

Presenting Author: Chandra Turpen, University of Maryland, College Park

Additional Author | Patrick R. Banner, University of Maryland, College Park • Additional Author | Robert P Dalka, University of Maryland, College Park • Additional Author | Elise Fiala, University of Maryland, College Park • Additional Author | Bryan Rezende, University of Maryland, College Park

Drawing on recent experiences teaching Modern Physics together at the University of Maryland, we will share our instructional team's critical reflections on our course design and collaborations. Our instructional team worked to value students' wellbeing and cultivate students' capabilities, self-efficacy and proudness. We acknowledge the values-aligned instructional materials from other physics educators that laid the foundation for our work. We illustrate how our holistic understanding of educational research results informed our course's policies and practices. We share the logic behind and the pragmatics of implementing some of our core instructional practices. These instructional policies and practices include: (1) introducing and monitoring discussion norms in class, (2) gathering systematic information on where our students are at in their understanding, (3) adapting instruction to meet students where they are, (4) creating opportunities for students to puzzle over phenomena with their peers both in and out of class, (5) celebrating and giving feedback, (6) developing structures for revising work, (7) reducing students' sense of overwhelm, and (8) humanizing physics learning. In combination, we see promising initial evidence that these instructional practices are reducing competitive cultures in our classroom in favor of an orientation that prioritizes learning and cooperation.

Session F12: Panel: Exploring Astronomy through Touch Using 3D Printing

Location: Meeting Room 03 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Thomas Madura

Move beyond simple pictures and animations with 3D printing to provide students with an opportunity to use cutting-edge technology found in professional settings and allow them to explore complex models that can be created and revised relatively rapidly. Research suggests student-developed models encourage discussion and a more in-depth learning of science content. Students' 3D models also represent their scientific understanding at a specific point in time, helping provide a physical portfolio of science learning. The rise of 3D printing in science education can be understood by examining the skills developed during hands-on activities, including problem-solving, critical and spatial thinking, patience, and resilience. In this panel session, participants will learn about 3D printing technologies, explore a variety of example 3D-printed astronomy models and associated activities, and learn ways to find, design, and 3D print 3D models. Recent examples from astronomy will include 3D constellations, stars, stellar evolution, planets, galaxies, and more. Finally, participants will learn how 3D printing and tactile learning are especially beneficial for students with blindness/visual impairments. Most available software and model files are free, and no prior experience is necessary.

Session F13: Workshop 2: Accessibility and Inclusivity in HS Physics Classrooms

Location: Meeting Room 09 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Tuesday, July 18, 2023 **Presider:** Santa Tejeda

Interactive (e.g. panel, round table discussion, hands-on activity) | Making Physics Accessible: A Pedagogy for Engaging High School Students Using Socio-Scientific Issues (SSI)

Presenting Author: Dylan Fedell, Palisades School District

Co-presenting Author | Thomas Limoges

In this workshop, participants will learn how to develop and implement a multi-step pedagogy that engages students using SSI (debatable issues) to teach scientific concepts. Derived from methods developed by the USTRIVE (Understanding STEM Teaching Through Integrated Contexts in Everyday Life) Program, this workshop is specifically designed for the high school physics teacher. By reframing curricular content already taught by the teacher, a debatable issue introduces and guides each curricular unit by engaging students at the intersection of their current level of scientific understanding and the world outside of the classroom. Students are then navigated through this multi-step process, which deepens their understanding of physics while at the same time developing their stance on the issue using evidence to support their claim. New learning in both science content and student agency aspects allows students to leave the classroom experience empowered to make real changes to their surroundings. Teachers will leave this workshop with hands-on experience engaging in the SSI process from a learner's perspective, and with a framework for developing and implementing their own.

Interactive (e.g. panel, round table discussion, hands-on activity) | Motivating HS Physics Learning by Designing for Justice with OpenSciEd HS

Presenting Author: Zoe Buck Bracey, BSCS Science Learning

Designing for justice in introductory physics means centering inquiry on phenomena that cross the artificial boundary between human and natural systems. The result is physics instruction that not only teaches students to understand the natural world, but broadens their perspectives on how humans fit into natural systems, what constitutes science, and what they can accomplish using physics. In high school, some of the design problems that students are noticing in the world may feel overwhelming, but breaking them down using the ideas and practices of physics can help students find hope and resilience. For example in OpenSciEd High School Physics, students ask questions like: How can we design more reliable systems to meet our community's energy needs? What can we do to make driving safer for everyone? To answer these, students must use physics ideas and practices to understand/think creatively about design problems that emerge from complex systems at the nature-human divide. Consider how instruction can support students in making positive changes in their communities. Explore how in OpenSciEd HS Physics, students use science ideas and practices to make sense of design problems that emerge from complex systems at the nature-human divide.

PLENARY: TEAM-UP Together: Supporting African American Student Success through Systemic Change TEAM UP Together Update, *Arlene M. Knowles*

Arlene Knowles

The 2020 TEAM-UP report, The Time Is Now: Systemic Changes to Increase African Americans with Bachelor's Degrees in Physics and Astronomy, states that unsupportive environments in many physics and astronomy departments and enormous financial challenges faced by African American students contributed to their underrepresentation in these fields. To address these issues systemically, TEAM-UP Together (TU-T), a new collective action initiative led by the American Institute of Physics, American Association of Physics Teachers, American Astronomical Society, American Physical Society and the Society of Physics Students, was started. TEAM-UP Together takes a multipronged, multi-layered approach to support the scientific community in taking the next bold step to double the number of African American students earning physics and astronomy bachelor's degrees annually by 2030. This program provides direct support to Black students, while providing funding and resources to physics and astronomy departments committed to doing the work needed to address STEM equity at their institution and design programs that support the success of Black students. In this plenary, Ms. Knowles will discuss the work that TU-T is doing to engage the community in this program, the impact the program is having on students today, and the future plans for creating systemic change that will transform the education of students, especially, Black students.

AAPT PHYSICS EDUCATION®

Tuesday, July 18
11:30 a.m.–12:30 p.m.
Ballroom A01

AWARDS: The 2023 Paul Zitzewitz Excellence in K-12 Physics Teaching Award

Alice Flarend

Alice Flarend

The Power of Words

We come to AAPT meetings to talk about physics. We share ideas and collaborate in order to find that perfect analogy to describe potential energy or how to setup a demo. Many conversations result in thought-provoking questions from peers about how or why we do certain things. These communications help us learn. We improve our understanding and, ultimately, our work.

I will argue language is an often overlooked but powerful pedagogical tool in the classroom. Of course, we all talk to our students, but do we talk with our students? Are we the only ones talking? Using language for learning means not only the language a teacher uses in explaining ideas, but also the opportunities the student has to communicate. Students have different experiences that influence their path to building an interconnected model of the world of physics. In building a more robust and nuanced model, they need to share their understandings, explain their unique connections and evaluate the ideas of others. Physics classroom should be filled with student voices and student ideas.

Catherine Herne

Homer Dodge Distinguished Service Citation

Catherine Herne

AAPT Fellow

Lin Ding

Safe Solar Observing Share-A-Thon

Location: Outdoor Pavilion **Sponsor:** Committee on Space Science and Astronomy **Time:** 12:30–2 p.m **Date:** Tuesday, July 18, 2023
Presider: Richard Gelderman

More than a dozen hands-on activities will be set up outside the Convention Center. At these stations, volunteers will share ways for safely observing the Sun. Solar observing can be an enjoyable and engaging part of every science class. When students, parents, and administrators experience solar observing as a safe and routine activity, it will be straightforward to view the Sun during the two upcoming solar eclipse events.

Session G01: Fostering Community through Professional Learning Opportunities

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Christina Milotte

G01-01 (2:00 to 2:12 PM Tuesday) | Contributed Talk | Preparing Teachers to Support All Students in the UTeach Model

Presenting Author: Danielle Maldonado, West Virginia University

Additional Author | Nancy Spillane, West Virginia University (retired)

Additional Author | Elaine Christman, West Virginia University

Additional Author | Danielle Maldonado, West Virginia University

This talk 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.

G01-02 (2:12 to 2:24 PM Tuesday) | Contributed Talk | Strengthening the Physics Teacher Preparation Program Guided by the PhysTEC Community

Presenting Author: Douglas Petkie, Worcester Polytechnic Institute

Additional Author | Rudra Kafle, Worcester Polytechnic Institute

Additional Author | Thomas Noviello, Worcester Polytechnic Institute

Additional Author | Jillian DiBonaventura, Worcester Polytechnic Institute

Worcester Polytechnic Institute (WPI) is completing its fourth year as a Physics Teacher Education Coalition (PhysTEC) Comprehensive site funded by the American Physical Society that has support for the program from the National Science Foundation (Award Number: 1707990). WPI is a small, private research institute located in central Massachusetts and as a polytechnic, most students are STEM majors. The Physics Department collaborates with the STEM Education Center to support students in a program of study that results in a degree in a STEM discipline and a Massachusetts Initial Teaching License in physics within the context of WPI's Project Based Learning Curriculum. We will discuss and reflect on how we utilized and adopted PhysTEC resources, such as the PETPA rubric, and Get the Facts Out resources, to create a supportive community environment to champion teaching as a career pathway for our students. We will also discuss the internal and external partnerships that are important to the ecosystem of supporting pre-service and in-service physics teachers in our region.

G01-03 (2:24 to 2:36 PM Tuesday) | Contributed Talk | Classroom Network Analysis for Pedagogical Decision Making: Interpretations and Didactic Innovations of Pre-service and In-service Science Teachers

Presenting Author: Javier Pulgar, Physics Department, Universidad del Bio Bio, Chile

Additional Author | Freddy Vargas, Physics Department, Universidad de Concepcion, Chile

Additional Author | Iván Sánchez, Physics Department, Universidad del Bío Bío

Additional Author | Carmen Espinoza, Didactics Department, Universidad Católica de la Santísima Concepción, Chile

Active learning methodologies, mostly grouped-based, are assumed to be effective depending on the content and age, but regardless of the set of social relationships embedded in the classroom. The effectiveness of group work clashes with the students' readiness to work in groups, and with teachers' skills to recognize optimal grouping mechanisms and guidance. Here, Social Network Analysis (SNA) emerges as an informative tool for educators. We conducted a workshop to introduce principles for effective collaboration based on research in SNA in PER and education. Participants were a sample of pre-service (N=60) and in-service science and mathematics teachers (N=10), who were later asked to interpret different visualizations of a classroom collaboration network (CCN) based on students' gender (binary); friendship; and academic popularity. Additionally, participants had to recognize problems in the CCN, and then pose pedagogical decisions to teach scientific content and to overcome such issues. After coding for emergent themes and categories, responses covered mechanisms such as gender homophily, information diffusion and problems with social inclusion. Pedagogical decision centered around active learning and group activities, but without in-depth organizational/managerial details, like grouping strategies or the encouragement of between-group interactions. We further discuss the implications of this evidence and future research.

G01-04 (2:36 to 2:48 PM Tuesday) | Contributed Talk | Research-Practice Partnerships to Counter High School Teachers Isolation through a Community of Practice Model

Presenting Author: Isaura Gallegos, Harvard University

Additional Author | Eric Mazur, Harvard University

Teacher-Initiated Projects (TIPs) are research-practice partnerships (RPPs) between physics teachers and physics education researchers to improve physics education, in the classroom. The TIPs are a part of the broader Physics of Living Systems Teacher (PoLS-T) Network and were established to address physics teacher concerns, namely, the lack of resources to implement evidence-based improvements in their physics classrooms and physics teacher isolation. The focus of this talk will be on the initial cohort of ten TIP collaborators and fostering RPPs in an authentic and mutually beneficial way, while also establishing a community of practice to counter

physics teacher isolation. Further, TIPs provide an example of how collaborative partnerships that center teacher expertise and leverage researcher resources can improve physics education.

Session G02: Astronomy and the Search for Life in the Universe I

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Ann Schmiedekamp

G02-02 (2:00 to 2:24 PM Tuesday) | | The SETI Institute and Unistellar Citizen Science Program.

Presenting Author: Franck Marchis, SETI Institute & Unistellar

Additional Author | Daniel O'Conner Peluso, SETI Institute & USQ

Additional Author | Tom M. Esposito, Unistellar & SETI Institute

SETI Institute has initiated a partnership with Unistellar in 2017 to create a dynamic and cutting edge citizen science program with the company Unistellar which builds robotic, smart and powerful telescopes for everybody. The network composed of more than 10,000 eVscopes is growing every day and has conducted successful observations of exoplanets, asteroids and human-made artifacts like JWST and the DART missions. Thanks to a generous grant from the Gordon and Betty Moore Foundation, the SETI Institute donated Unistellar eVscopes to community college professors that teach astronomy. This new program, called the Unistellar College Astronomy Network (UCAN), has the goal of encouraging observational astronomy and inquiry-based science education experiences for teachers and students. We will present our network, the recent activity in education and outreach and how we believe we can create unique opportunities for students and their instructors to learn science by doing science and train the next generation of space explorers who will one day live and thrive in space.

G02-02 (2:24 to 2:48 PM Tuesday) | | Breakthrough Listen: Humanity's Best Chance Yet to Make Contach

Presenting Author: Steve Croft, UC Berkeley

Breakthrough Listen (BL) is the most comprehensive, intensive, and sensitive search for technosignatures (technological indicators of extraterrestrial intelligence) to date. Operating on several of the world's most powerful telescopes, BL has deployed powerful computers capable of tuning to billions of radio channels at once. We are carrying out surveys of Solar System objects, nearby stars, the center and plane of our Milky Way galaxy, and nearby galaxies, as well as observations of fast radio bursts and other interesting astrophysical sources. I will describe what we're searching for, how we conduct our searches, and how the search for intelligent life is complementary to the search for indicators of biology on other worlds. I will also share some recent applications of machine learning on our data and how we're hopeful that artificial intelligence might hold the key to finding extraterrestrial intelligence. Our research informs and inspires as we try to answer one of the most profound questions in science: Are we alone? I'll also share some pedagogical materials that we've used to engage high school students as well as our undergraduate research interns in hands-on analysis of data from our search.

Session G03: Assessing Upper-Level Courses

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Keith Zengel

G03-01 (2:00 to 2:12 PM Tuesday) | Contributed Talk | A Research-based Assessment to Help You Improve Your Course

Presenting Author: James Laverty, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | Alexander Adamson, Kansas State University

Additional Author | Tyler Garcia, Kansas State University

Additional Author | Michael Freeman, University of Colorado Boulder

Additional Author | Bill Bridges, Kansas State University

Research Based Assessments have a productive and storied history in PER. While useful for conducting research on student learning, their utility has been limited for instructors interested in improving their courses. We are finalizing the development of the Thermal and Statistical Physics Assessment (TaSPA), which is aimed at upper level undergraduate courses. When complete, TaSPA will be online, fully automated, and allow instructors to choose learning goals that align with their course. The TaSPA then builds the assessment to gather evidence of students' abilities, then use the results to provide actionable feedback to the instructor. This feedback is designed to support instructors who want to improve their course by identifying whether students are meeting learning goals and are looking for ideas about what to work on improving in their course. To do this, we have leveraged three-dimensional learning, evidence-centered design, and self-regulated learning. In this talk, we will give an overview of the TaSPA and its uses. If you are interested in this work, this talk will also highlight ways you can get involved and help us improve the TaSPA.

G03-02 (2:12 to 2:24 PM Tuesday) | Contributed Talk | Content Validation of Tasks through Evidence from Students in Assessments through Interviews

Presenting Author: Tyler Garcia, Kansas State University

Additional Author | Michael Freeman, University of Colorado Boulder

Additional Author | Alexander Adamson, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Additional Author | James T Laverty, Kansas State University

We are working on an assessment using evidence-centered design which we are calling the Thermal and Statistical Physics Assessment (TaSPA). To create tasks, we are using a knowledge-in-use framework that focuses on identifying the evidence we need to see in student answers to claim students are able to do science, not just know science. These "evidence statements" are the observable features students generate that show they have knowledge to complete a claim. Since these tasks are designed to elicit student's evidence towards a claim, we need to determine a way to validate the tasks based on the extensive focus towards students using evidence when solving tasks. Current literature focuses on bringing in experts to validate that the tasks align with learning performances and expected evidence of these performances. We are looking to expand on this literature by articulating a way to validate tasks that use evidence-centered design through looking at students' evidence

statements. To validate TaSPA tasks, we have conducted and analyzed student think-aloud interviews in regards to them answering four free-response tasks. In these interviews we are explicitly looking for the appearance of specific evidence statements. We will report a detailed process on how we validated the tasks.

G03-03 (2:24 to 2:36 PM Tuesday) | Contributed Talk) | Students' Reflections on Past Experiences When Encountering a Novel Representation of Electrostatic Potentials in Upper Division E&M

Presenting Author: Dustin Treece, Oregon State University

Additional Author | Corinne A Manogue, Oregon State University

Pairs of junior-level physics majors were interviewed using an interactive GeoGebra applet which displays a cross-section of an electric potential due to a collection of point charges with adjustable parameters. This physical system is analogous to, but different from, classroom experiences the interviewees had during their first upper-division course in electrostatics and a paired computational lab. We examine which past experiences were recalled by the participants and which were the most salient while orienting to the applet. Physicists leverage their past experiences to solve novel problems. Studying which experiences students recall and invoke when they encounter new challenges may help us build more effective classroom experiences.
Supported in part by NSF grants: DUE 1836603 and DUE 1836604

G03-04 (2:36 to 2:48 PM Tuesday) | Contributed Talk | Framework-based Problem Solving Tutorials for Upper-division Electromagnetism

Presenting Author: Andrew Mason, University of Central Arkansas

Co-presenting Author | Dorian Baldwin-Bott, Brigham Young University

Additional Author | Grant Miller, Brigham Young University

Additional Author | John S. Colton, Brigham Young University

Current literature on upper-division problem solving tutorials has thus far tended to focus on specific aspects of problem solving, e.g. conceptual understanding or mathematical reasoning, or on specific topics within an upper-division course, e.g. electron spin in quantum mechanics. This talk discusses aspects of a preliminary study with two long-term goals: to attempt a more comprehensive problem solving framework treatment within a set of tutorials for upper-division electromagnetism, and/or to adapt the tutorials to be more flexible for different instructional situations (e.g. different institution types). Work presented thus far focuses on a developed subset of prototype tutorials with a more explicit theoretical problem solving framework in mind, e.g. the Minnesota model as framed within cognitive apprenticeship. We discuss plans for testing these tutorials in sample courses to address strengths, limitations, and needed adaptations of these prototypes.

Session G04: PER & DEI I

Location: Ballroom A05 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Jayson Nissen

G04-01 (2:00 to 2:12 PM Tuesday) | Contributed Talk | Inequity in, Inequity Out? Incoming Grades and Academic Outcomes for Marginalized Students on Physics Degrees

Presenting Author: Astra Sword, The Open University

Additional Author | Rachel Hilliam, The Open University

Additional Author | Mark Jones, The Open University

Additional Author | Sally Jordan, The Open University

Common wisdom holds—and the data supports—that success in secondary education (e.g., high school) helps students to succeed in their degree studies; at least, on average. For students from marginalized backgrounds, this can, in theory, lead to a 'double disadvantage,' with any inequity they faced in secondary education interacting with the barriers they face in higher education. Understanding the nature of this interaction is vital for educators in both secondary and higher education that are seeking to support students from marginalized backgrounds. In this study, we use a remarkably large dataset (approx. 32,000 students) to examine the relationship between incoming, secondary education grades and academic outcomes for students studying physics degrees in the United Kingdom over the 8 years between 2012/13 and 2019/20, and how this relationship changes with respect to age, disability status, ethnicity, gender, and socioeconomic status. In this talk we will report on how the overall trend between incoming grades and outcomes has changed over this period; identify how this trend breaks down for specific demographic groups; and discuss the implications of this data for supporting marginalized students to succeed on physics degree programs.

G04-02 (2:12 to 2:24 PM Tuesday) | Contributed Talk | Analytical Methods of Measuring the Effect of Practicing a Skill on Exam Performance

Presenting Author: Andrew Heckler, The Ohio State University

Additional Author | Harish Moni Prakash, The Ohio State University

Additional Author | Qiaoyi Liu, The Ohio State University

In our research we would like to determine the extent to which student practice on skills relevant to introductory physics courses are improving student performance on physics course exams, compared, for example, to a control group of students who did not practice the skill. We are also interested in determining the extent to which any effect of the practice depends on some measure of the overall performance level of the student. Analyzing such data may require different methods, depending on the nature of a given skill and the level of relevance of the exam items for that skill. For example, if the skill is very specific, such as determining the sign of mechanical work, then there may only be one or two items in the exam that have any relevant to that skill. On the other extreme, the skill may be more general, like the ability to perform simple algebraic operations, and it may be that all or nearly all of the items are relevant. In this talk we will present and discuss several methods that apply to these differing cases, provide some examples, and discuss some of the persistent and perhaps unavoidable issues with these methods.
This material is based upon work supported by the National Science Foundation under DUE IUSE Grant No. 1914709.

G04-03 (2:24 to 2:36 PM Tuesday) | Contributed Talk | Evolution of Accuracy and Speed on Basic Skills, and Their Predictiveness on Course Grades

Presenting Author: Harish Moni Prakash, Ohio State University

Additional Author | Andrew F Heckler, Ohio State University

We pre and post-tested students in introductory algebra and calculus-based Physics courses on basic STEM skills, and found that controlling for accuracy, speed was on average positively though somewhat weakly correlated with exam scores, and not correlated with non-exam scores. From pre to post-test, on average students improved in accuracy and speed. However, changes in accuracy and speed depended on the initial accuracy and speed. We found that students who started with low initial scores were likely to slow down from pre to post, or at least not speed up as much. We hypothesized that students who scored low initially and slowed down would tend to score better on the post-test than those who did not slow down, and correlational evidence was found to support this. Because past research has found demographic disparities in grades, we also look for differences between gender, race, citizenship, and first-generation status in speed and the relations between speed, accuracy, and grades discussed above. And lastly, to improve our models for predicting exam and non-exam grade components, we attempt to include the different speed-accuracy evolution behaviors discovered above in addition to the initial accuracy and speed.
This research was primarily supported by an NSF IUSE grant, award 1914709.

G04-04 (2:36 to 2:48 PM Tuesday) | Contributed Talk | How Physics Motivational Beliefs Predict Men and Women's Outcomes

Presenting Author: Sonja Cwik

Additional Author | Yangqiuting Li

Additional Author | Chandralekha Singh

Prior research shows that in physics, students' physics identity depends on their physics self-efficacy, perceived recognition by others, and their interest. In this study, we investigated how these ends of the motivational beliefs for bioscience majors enrolled in a mandatory physics course sequence predict their overall outcomes. We find that bioscience majors' physics motivational beliefs predict their outcomes. We also find that on average, women majoring in bioscience had lower physics motivational beliefs than men even though women were not underrepresented in the physics course

Session G05: PER about Student Collaboration

Location: Ballroom A06 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Joss Ives

G05-01 (2:00 to 2:12 PM Tuesday) | Contributed Talk | Exploring Students' Ideas about Collaboration Using Socio-metacognition

Presenting Author: Ezra Reisman, Western Washington University

Additional Author | Thanh Lê, Western Washington University

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Carolina Alvarado, California State University, Chico

Additional Author | Josie Allen, California State University, Chico

Additional Author | William Henriquez, California State University, Chico

Physics classes are becoming more collaborative and group work based. However, students have different conceptions of collaboration which can pose challenges for groups to engage in productive collaborative work. This study is focused on students' views of collaboration and how it aligns with the ways in which students engage in the negotiation of their collective understanding. We interviewed 25 students that took a highly collaborative, group work based physics class for preservice K-8 teachers at Western Washington University and California State University, Chico. We conducted semi-structured interviews with stimulated recall protocol. We focused on the responses to questions on group dynamics. We use Borge's socio-metacognitive framework for the analysis, which describes how a group monitors and regulates their interactions and collective learning processes. We present student quotes reflecting on their experiences collaborating in the classroom and compare them with Borges' ideas about student collaboration. Finally, we conclude by presenting recommendations for instructors to better support their students to engage in collaboration.

G05-02 (2:12 to 2:24 PM Tuesday) | Contributed Talk | Examining Students' Navigation through the Experimental Process While Faced with Different Technical Impasses

Presenting Author: William Henriquez, CSU Chico

Additional Author | Josephine Allen, CSU Chico

Additional Author | Than Lê, Western Washington University

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Carolina Alvarado, CSU Chico

Collaborative learning environments are known to facilitate students' learning process by fostering support from their peers. Our study centers on students engaging in socio-metacognition, referring to how the groups monitor and regulate their collective learning processes to then create shared understanding. We analyze a group's approach to data collection as they face multiple impasses during the experimentation process, including malfunctions in their data collection process. Through the lens of socio-metacognition, we expand the analysis of discourse patterns to include students' communication through the manipulation of their experimentation to study students' collective information synthesis and knowledge negotiation. This qualitative case study follows a group of three pre-service k-8 teachers in an undergraduate physics course. The motivation for this selection was the vocal exchange of ideas between group members, leading to engagement and efforts to resolve their experimental difficulties. We video-recorded the students' classroom interactions to analyze their in-the-moment interactions, and we used an expanded interpretation of Borges to include non-verbal communication, et al. socio-metacognition framework. Our study supports instructors who foster group collaboration through experimentation to reconsider the ways in which students engage in the negotiation of their collective understanding.

G05-03 (2:24 to 2:36 PM Tuesday) | Contributed Talk | Exploring Students' Collective Interactions through Understanding Their Individual Forms of Knowing

Presenting Author: Josephine Allen, California State University, Chico

Additional Author | William Henriquez, California State University, Chico

Additional Author | Thahn Lê, Western Washington University

Additional Author | Andrew Bourdreaux, Western Washington University

Additional Author | Jayson Nissen , Nissen ER&D

Additional Author | Carolina Alvarado, California State University, Chico

In a collaborative environment for physics education, studying the role of socio-metacognition, or how a group monitors and regulates their interactions and collective learning processes, allows us to understand the student's experiences. This qualitative research project collected data from a physics undergraduate course for future k-8 teachers. Using video recordings from the classroom and individual, semi-structured interviews from two of the three group members, this case study explores a group of three students that distinguished themselves from the rest through their vocality and determination to understand the activities. This group showed attempts to engage in socio-metacognitive patterns, both successfully and unsuccessfully. For example, students will explicitly communicate their need to visualize the thinking process together using a whiteboard, while another student will request to first work individually on their own lab to then be followed by group discourse. We analyze students' views of collaboration and reflection on their classroom interactions to understand their personal epistemology, or the way they view knowing. We present how students' failed attempts at socio-metacognitive patterns can be understood through the differing perspectives of knowing they hold while collaborating as a group.

G05-04 (2:36 to 2:48 PM Tuesday) | Contributed Talk | An Example of Shared Resources in Student Problem-Solving of Spherical Unit Vectors in Upper-Level E&M

Presenting Author: Brant Hinrichs, Drury University

Additional Author | Ying Cao, Drury University

We are interested in understanding the different ways that students collaborate to solve physics problems. One mechanism we have recently observed in the context of spherical unit vectors in upper-division E&M, is that students first co-construct a visual representation, which we call a shared resource, that they then use to solve the problem. This talk very briefly introduces the theoretical framework of shared resources and then goes into greater detail about how an identified shared resource helped two students navigate through some of the difficulties of a challenging problem. In particular we illustrate how the shared resource externalized and coordinated bits of productive thinking that each student brought to the collaboration. We conclude with some implications for possible instructional strategies.

Session G06: PER into Student and Instructor Attitudes about Assessment

Location: Ballroom A07 **Sponsor:** Committee on Research in Physics Education **Time:** 2–3 p.m.
Date: Tuesday, July 18, 2023 **Presider:** Stephanie Chasteen

G06-01 (2:00 to 2:12 PM Tuesday) | Contributed Talk | Gentle Assessment: Inclusion of Affect in Instructors' Computational Physics Assessment Decision-making

Presenting Author: Hannah Sabo, University of Oslo

Additional Author | Tor Ole B Odden, University of Oslo

Additional Author | Marcus D Caballero, Michigan State University

Additional Author | Sebastian G Winther-Larsen

Computation is making its way into physics teaching at the undergraduate level. However, we don't have a lot of understanding of how to best assess computational physics. So, we interviewed fourteen university instructors who teach physics courses which include computational elements to investigate their learning goals, support techniques, and assessment methods. We used grounded theory to analyze the interviews and found that many instructors use a grading approach which we call "gentle assessment," a grading rationale often employed in computational physics settings (usually introductory) designed to reduce students' negative affect and (feelings of) risk around the introduction of computation into physics courses. In this presentation, I describe gentle assessment and its common characteristics and contrast it with grading practices of non-computational physics and conclude with implications for assessment of computational physics.

G06-02 (2:12 to 2:24 PM Tuesday) | Contributed Talk | A Short Examination of Students' Perception of Instructor Exam Marking Practices

Presenting Author: Mark Swartz, University of North Florida

Additional Author | Sarah Nguyen, University of North Florida

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

Additional Author | W. Brian Lane, University of North Florida

The goal of this project was to observe how physics students react to differences in instructor grading styles. Based off of previous work done by Hendersen et. al., two styles were compared: an instructor who places the burden of proof on the student (student burden of proof, or S-BoP), and an instructor who places the burden of proof on themselves (instructor burden of proof, or I-BoP). To study this, we created three hypothetical student responses to a kinematics question on which we placed markings from a hypothetical instructor (either Professor Oval, the S-BoP professor, or Professor Circle, the I-BoP professor). Participants were shown the same three hypothetical students' work marked by the two different instructors and were asked to fill out a questionnaire regarding the two instructors' grading styles. General results from this questionnaire will be discussed. Some results show that grading practices surrounding partial credit can potentially have an negative impact on student willingness to show work or provide justification for their answers.

G06-03 (2:24 to 2:36 PM Tuesday) | Contributed Talk | "I'm Just Gonna Chegg it": Preliminary Insights from Auto-ethnographic Accounts of Students' Use of Homework Solutions

Presenting Author: Alexander Conte, University of Maryland, College Park

In this presentation, we will share preliminary findings from a new NSF-funded study of academic integrity in the context of students using solutions while solving homework problems, in an intermediate Engineering dynamics course. The goal of the project is to study students' views about, and decision-making around, using homework solutions, within the context of their textured and varied lives. These views and decisions arise contextually from a complex interaction of their past experiences, course and peer culture, and other factors—rather than just from stable student characteristics. Data come from a variety of sources, including course observations, student interviews, and students' bi-weekly audio-recorded reflections on doing homework and experiences in the course and from their lives more broadly. Students use online solutions in a wide variety of ways, with few of them just blindly copying solutions. How they actually use solutions depends on how supported they feel in the course, how overwhelmed they feel in their lives, and what counts as learning for them, among other factors.

G06-04 (2:36 to 2:48 PM Tuesday) | Contributed Talk | Examining Student Experiences and Agency on Ungraded Quizzes

Presenting Author: Sarah Nguyen, University of North Florida

Additional Author | Mark Swartz, University of North Florida

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

Additional Author | W. Brian Lane, University of North Florida

Additional Author | Thanh K. Lê, Western Washington University

The term (un)grading used in a physics education setting typically refers to the practice in which instructors reduce the perceived importance of letter grades and in turn, focus on giving students more agency over their learning and providing quality feedback regarding student's learning outcomes. To examine the impact of this method on students' experience of physics, we (un)graded two out of seven total bi-weekly quizzes in an Algebra-based Physics II course by asking the students to reflect on their performance on the quiz and suggest a grade for themselves. On every quiz, several Likert-style questions were asked assessing motivation, anxiety, confidence, curiosity, etc. Additionally, at the end of these quizzes, students were offered a choice between two bonus questions: a more difficult "life-sciences application" problem and a less difficult "pure physics" problem. Comparisons of student responses between the graded and ungraded quizzes are discussed.

Session G07: State and Institutional Challenges for Physics Teacher Prep

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** John Stewart

G07-01 (2:00 to 2:24 PM Tuesday) | | Sometimes You Lose (on Paper): Finding Ways for Good Teacher Prep to Win!

Presenting Author: Elaine Christman, West Virginia University

Co-presenting Author | Gay B Stewart, West Virginia University

State Departments of Education set requirements that teacher preparation programs must follow. Often, institutional contacts are primarily concerned with elementary educator preparation. The focus of elementary educator preparation is significantly different than that of secondary educator preparation, which by necessity has a much larger focus on content and content-specific pedagogy. Proposed policy changes may seem sensible in the elementary context, but cause problems for secondary. Staying informed about such policy changes can be difficult, and seeking to change policy once it is enacted even more difficult. In this talk we will present a policy change that makes recruiting high school physics teachers extremely challenging, the year-long residency, the process by which we utterly failed to change that policy, and how we then reframed the policy to both fulfill the policy and serve our students.

G07-02 (2:24 to 2:48 PM Tuesday) | | Surviving the Slings and Arrows of Outrageous Fortune

Presenting Author: Christopher Fischer, University of Kansas

STEM teacher preparation programs are often targets for cuts or termination owing to the small enrollment in these programs and the frequent lack of advocacy for these programs among the STEM departments. I will discuss how I led efforts among STEM departments at the University of Kansas to collaborate with the university's School of Education to resurrect and reorganize the university's STEM teacher preparation program after it was eliminated. This multi-year process faced multiple headwinds but nevertheless resulted in greater ownership of STEM teacher preparation by all stakeholders on campus, including better coordination of recruitment efforts.

G07-03 (2:48 to 3:00 PM Tuesday) | Contributed Talk | Community Building: Addressing Recruitment and Retention in the Rutgers University Physics Teacher Preparation Program

Presenting Author: Robert Zisk, Rutgers University

As with all states in the United States, schools in New Jersey struggle to find enough qualified and certified Physics Teachers. In this talk, I will highlight the efforts of the Rutgers University Graduate School of Education's Physics Teacher Preparation program, a program started over 20 years ago that consistently trains 5 – 10 physics teachers a year, to recruit and train teachers and ensure that our graduates stay in the classroom. I will discuss the recruitment process, starting with students in high school physics classes, induction into the teacher preparation program, the training the students receive, and the community that we have developed. This community keeps our graduates in the profession and helps them to continue to learn, while also helping the program to recruit new teachers. In this talk, I will also discuss how we have developed school and district partnerships, which provide us with internship placements and have resulted in communities of our graduates being formed within the schools.

Session G08: Improving Student Learning of Quantum Mechanics II

Location: Ballroom A09 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Alexandru Maries

G08-01 (2:00 to 2:24 AM Tuesday) | | Preparing Students for the Second Quantum Revolution Using Research-Validated Learning Tools

Presenting Author: Chandralekha Singh, University of Pittsburgh

We are in the midst of the second quantum revolution. To help improve student understanding of quantum concepts, we have been conducting investigation of the difficulties that students have in learning quantum mechanics and we are using research as a guide to develop Quantum Interactive Learning Tutorials (QuILTs) as well as tools for peer-instruction. The goal of QuILTs and peer-instruction tools is to actively engage students in the learning process and to help them build links between the formalism and the conceptual aspects of quantum physics. These learning tools focus on helping students integrate qualitative and quantitative understanding without compromising technical content. I will discuss the types of efforts I have been involved in.
We thank the National Science Foundation for support.

G08-02 (2:24 to 2:48 AM Tuesday) | | Modern Proposals for Teaching Quantum Physics at High School

Presenting Author: Gesche Pospiech, TU Dresden, Germany

This contribution presents modern teaching approaches to quantum physics for high school. First, the potentials of two-state systems and possible realisations, such as polarisation of photons or spin of electrons, are discussed. Criteria of career orientation for students, relevance of general education and interest of learners are taken into account: What role should the basic principles of quantum physics play as teaching objectives? What space should quantum technologies occupy as a current field of research? Possibilities of formalisation at the elementary level for high school are also presented. In order to discuss empirical results on qualitative approaches and approaches using formalisation, experiences from various implementations are reported.

Session G09: Research Validated Interactive Lecture Demonstrations to Improve Learning in Lecture (and at Home)

Location: Ballroom A10 **Sponsors:** Committee on Educational Technologies **Cosponsor:** Committee on Research in Physics Education
Time: 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** David Sokoloff

G09-01 (2:00 to 2:24 PM) | | Research Validated Interactive Lecture Demonstrations: A Strategy to Improve Learning in Lecture and at Home

Presenting Author: David Sokoloff, University of Oregon

Additional 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). The other invited talk in this session will present evidence that ILDs have been effective in 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. https://pages.uoregon.edu/sokoloff/HomeAdaptedILDs.html

G09-02 (2:24 to 2:48 PM) | | Interactive Lecture Demonstrations: Effectiveness in Teaching Concepts

Presenting Author: Ronald Thornton

David Sokoloff

The effectiveness of Interactive Lecture Demonstrations (ILDs) in teaching physics concepts has been studied using physics education research based, multiple-choice conceptual evaluations.(1) Results of such studies will be presented, including studies with clicker ILDs. These results should be encouraging to those who wish to improve conceptual learning in their introductory physics course.

Session G10: Effective Practices in Educational Technology

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Andy Gavrin

G10-01 (2:00 to 2:12 PM Tuesday) | Contributed Talk | ChatGPT Takes Physics Exam

Presenting Author: Brian Woodahl, IUPUI

Can ChatGPT help students learn introductory physics? How can we incorporate ChatGPT into our physics recitations? To illustrate the importance of ChatGPT, this past spring semester, ChatGPT took one of my exams in the first semester, algebra-based physics course on mechanics. I discuss how it performed, compare its score to the rest of the class (humans) and discuss how ChatGPT (Chat Generative Pretrained Transformer) has the potential to dramatically change the landscape in introductory physics courses.

G10-02 (2:12 to 2:24 PM Tuesday) | Contributed Talk | Interactive Video-Enhanced Tutorials (IVETs): Optimizing Use for Personalized Instruction in Problem-Solving

Presenting Author: Kathleen Koenig, University of Cincinnati

Additional Author | Alexandru Maries, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology

Addressing students' learning needs can be challenging, particularly in large enrollment courses and those involving students with wide ranges of abilities. To help

meet this challenge, we developed a suite of web-based interactive video-enhanced tutorials (IVETs), which guide students through expert-like problem-solving approaches for problems involving specific topics, such as conservation of energy. IVETs include video narration by a live person interspersed with branching multiple-choice questions to engage students. Feedback and hints are provided for incorrect and correct responses, much like one would provide during office hours. IVET design features that support personalized instruction will be discussed along with research outcomes that suggest best practices for implementation. Over 30 IVETs are now freely available (see compadre.org/ivet), covering most chapters taught within a two-semester introductory physics course. IVETs can be assigned with minimal instructor effort by distributing weblinks or embedding IVETs directly into LMS courses using SCORM packages. IVETs support remote, hybrid, and face-to-face courses. This work is partially supported by NSF DUE-1821391 and DUE-1821396.

Session G11: Making Physics Labs and Apparatus More Accessible

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Nathan Powers

G11-01 (2:00 to 2:24 PM) | | Deaf and Hard of Hearing Students in Laboratory Settings

Presenting Author: M. Jeannette Lawler, Brigham Young University

Additional Author | Michael Jones, Brigham Young University

Laboratory and experiential learning environments come with unique challenges for students who are deaf or hard of hearing (HoH). These challenges arise due to the ways in which environmental demands impact visual attention. Examples of the issues include the need to divide visual attention between equipment and interpreters, optics and astronomy labs that need to take place in the dark, group work where multiple students are sometimes speaking at once. This talk will include a summary of some of the challenges and a discussion of mitigating strategies. It will also include results of some studies on the use of augmented reality glasses as a technological approach to providing better access for deaf/HoH students.

G11-02 (2:24 to 2:48 PM) | | Affordances and Insights for Teaching Introductory Circuits to Sight Impaired Students

Presenting Author: Dan MacIsaac, SUNY Buffalo State University

Additional Author | Kathleen A Falconer, Institut für Physikdidaktik, Universität zu Köln

Additional Author | Manuela Welzel-Breuer, Physics Department, Pädagogische Hochschule University of Education, Heidelberg Germany

Additional Author | Pamela Detrois, Staatliche Schule für Blinde und Sehbehinderte in Ilvesheim, Germany

We describe affordances – simple modifications to equipment and procedures, and interventions for an introductory activity examining the classic relative brightness of one bulb in a circuit, two bulbs in series, and two in parallel circuits. Affordances for partially sighted students are straightforward, with slight but important adaptations to apparatus, lesson flow and timing. Affordances for profoundly blind students include using circuit representations on raised paper (swell paper) with and without Braille, and rigidly concrete circuits created with commercial apparatus. Given a second or two for thermal stabilization, sightless students can discriminate by touch amongst dark, partially lit and brightly lit incandescent bulbs for the traditional comparisons. We also discuss the need to establish physical and social trust and safety for blind children and undergraduate students in handling simple circuit elements.

Session G12: PER Early Career Topical Discussion

Location: Meeting Room 03 **Sponsor:** Committee on Research in Physics Education **Time:** 2–3 p.m.
Date: Tuesday, July 18, 2023 **Presider:** Katie Ansell

Postdocs, new faculty, and other junior Physics Education Research (PER) members are invited to this topical discussion to meet and discuss common issues. This session also 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 G13: Workshop 3: Demos and Hands-on Activities

Location: Meeting Room 09 **Sponsor:** AAPT **Time:** 2–3 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Deborah Skapik

G13-01 (2:00 to 2:24 PM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Cup of Physics: Hands-on Physics Activities Using Cups

Presenting Author: Bree Barnett Dreyfuss

Disposable, but reusable, cups made of plastic and paper can be used for a variety of hands-on experiments in a high school physics class. Using cheap materials like cups means most schools can afford to have more lab groups or even have students complete these individually. The familiarity with the materials often means students are more engaged and the concepts can feel more accessible. In this interactive session come learn about and build samples of different activities using these cups. Participants will hear about many different activities and will build a stripped down motor of Exploratorium design, a working electroscope, a model of a Brazilian instrument called a Cuica, engineer the best electrophorus design and more. Materials will be brought to build each so that everyone can take a sample with them. Participants will have a chance to discuss in small groups and share other similar ideas with the group as a whole.

G13-02 (2:24 to 2:48 PM) | Interactive (e.g. panel, round table discussion, hands-on activity) | Simple and Beautiful Experiments XIII by LADY CATS

Presenting Author: Kyoko Ishii, Tamagawa University

Co-presenting Author | Masako Tanemura, Osaka Kyoiku University

Co-presenting Author | Nobue Masuda, Iwate University

Our group name is LADY CATS (Creators of Activities for Teaching Science). We organized predominantly female science teachers from all levels of the educational system in Japan. We have demonstrated "Simple and beautiful experiments" twelve time since ICPE 2005. Our concepts of experiments are as follows: the "simple" experiments which the teachers in the world can utilize in their classes easily, the "beautiful" experiments in which children get interested, and the "essential" experiments which can demonstrate the principles of physics (Faraday motor, static electricity balloon, balance beam, surface tension etc.). We aim to encourage both students and elementary teachers who are not interested in physics. In this session, we introduce one example of hands on activities "Let's make a pan flute with straws". Many students say they like music, but physics and music are closely related, which we want to tell them. This is based on Pythagoras' idea as a musical scale. It is also an example of STEAM education. In addition, it is possible to provide education according to the developmental stages of elementary, junior high and high school.

Session H01: Fostering Community through Professional Learning Opportunities II

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Christina Milotte

H01-01 (3:00 to 3:12 PM Tuesday) | Contributed Talk | Identifying the Professional Development Needs of Middle School Science Teachers

Presenting Author: Debbie Andres, Paramus HS/Rutgers University

The underrepresentation of marginalized identities, such as women and people of color, continues to persist in the STEM workforce in the United States. A deeper look at the experiences of marginalized identities in their early exposures to STEM could provide insight into how to address this problem. One critical location for STEM development is the middle school (age 10-13) science classroom. While many studies focus on the experiences of students in the high school setting, the middle school classroom environment is a fertile ground for the development of students' interests in STEM. Here, younger students are exposed to multiple fields of science each year, creating a rich opportunity to develop pedagogical practices that meet the needs of all learners. However, as researchers, we are unaware of the professional development needs of middle school science teachers. To learn about teachers' needs, we conducted a series of interviews and observations to inform the development of a professional development program that meets the needs of both the classroom teachers and their students. This talk presents on the findings from a pilot study on current science teaching practices of middle school science teachers and future steps for professional development.

H01-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Describing a Faculty Online Learning Community about Disability

Presenting Author: Erin Scanlon, University of Connecticut

Additional Author | Joshua Hinostroza, University of Connecticut

Disability is an important aspect of human diversity. Previous research indicated that postsecondary instructors receive little training about supporting people with disabilities in the classroom setting. To address this lack of training, we hosted a faculty online learning community (FOLC) focused on disability and accessibility for faculty within the college of liberal arts and sciences at a large, research-intensive university in New England. At the end of the 10-week FOLC, we surveyed participants using the Inclusive Teaching Strategies Inventory (ITSI) regarding their beliefs about and use of inclusive teaching strategies within their teaching. In addition, at the end of the FOLC we surveyed participants about their experiences with and thoughts about the FOLC. The purpose of this presentation is to describe the FOLC as a model for professional development and to present the findings from the post-surveys to describe the impact of the FOLC on participants' instructional practice.

H01-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Preparing Faculty to Incorporate Belonging, Growth, and Purpose Mindsets in their Classes

Presenting Author: Jonathan Perry, University of Texas at Austin

Additional Author | Christina Markert, University of Texas at Austin

Additional Author | Eric Smith, University of Texas at Austin

Students entering into physics classes can often feel a lack of a sense of inclusion in the field, believe that failure is a judgement on their abilities, and lack an understanding of how to effectively learn. While many instructors work to address these, and other, challenges, they are often doing so individually. Efforts from the Texas Mindset Initiative have sought to improve on this through faculty fellowships that expose instructors to the underlying research of belonging, growth, and purpose mindsets, and help them to develop intentional practices to address student challenges. Instructors often work with a small group of peers aided by behavior scientists or instructional designers as they develop their individual practices. Here, we will share the structure and implementation of a semester-long professional development effort targeted at a cohort of physics faculty to develop such practices.

Session H02: Astronomy and the Search for Life in the Universe

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Ann Schmiedekamp

H02-02 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Scale and the Search for Habitable Worlds

Presenting Author: Mary Urquhart, University of Texas at Dallas

Habitability beyond the Earth is a complex topic that - along with the Drake Equation, star and planet formation, and the co-evolution of our planet and its biosphere - is part of an astrobiology course at the University of Texas at Dallas designed for both in-service and pre-service teachers. The scale of worlds in size and distance from their star is directly related to both planetary evolution and the concept of habitable zones. I will discuss how a 1 to 10 billion scale model of the Solar System inspired by permanent installations at the University of Colorado at Boulder and the National Mall has been extended to exoplanetary systems with Earth-like planets to facilitate discussions of habitable zones, differences in main sequence stellar luminosity by spectral class, differences in planetary systems, "Eyeball Earths", and more. Links to classroom-tested lesson plans and resources will be provided free to participants.

Session H03: Labs/Apparatus

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Keith Zengel

H03-01 (3:00 to 3:12 PM Tuesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Inexpensive Quantitative Doppler Effect with Pop Tubes and Slow Motion VIdeo Analysis

Presenting Author: James Vesenka, University of New England

Additional Author | MattheW Badali, University of New England

In this interactive introductory physics lab activity students explore the speed of a rotating "pop tube" using two independent techniques. Video analysis software enables calculation of the tangential speed. A rotating corrugated tube will draw air from the position of least motion, generating an air flow over the corrugation creating vortices that create audible resonance at specific angular velocities. Because the rotating tube has different tangential velocities, depending on the point along the tube from the axis of rotation, a range of Doppler shifted frequencies near the central peak can be extracted from an audio spectrum. The resonance frequencies are collected using a microphone situated in the plane of rotation. The Doppler shifted peak frequency can be analyzed to solve the speed of the moving tube, with the frequency extrema giving towards and away from the microphone. Lastly, the period of the audio spectrum (point of closest approach to the tube) and radius of the motion provides a third means of estimating the tangential speed. These results are then compared with those taken by video analysis. This activity provides students with a practical means of understanding how Doppler shifted waves can be analyzed to find information on relative motion.

H03-02 (3:12 to 3:24 PM) | Contributed Talk | Visualizing Energy Conservation Using PASCO Smart Carts

Presenting Author: Brenda Weiss, CSU Sacramento

Additional Author | Eliza Morris, CSU Sacramento

In our hands-on lab for calculus-based physics at CSUS, teams of students explore conservation of mechanical energy using PASCO smart carts. They predict kinetic, potential, and total mechanical energies, then use measurements of position and velocity to calculate and graph conservation of mechanical energy. Students also roll smart carts down a track and bounce them off their springs observing intervals where mechanical energy is conserved and changes in total mechanical energy due to an external force. Finally students explore the motion of bouncing balls, using their cart experiments as a model for changes in mechanical energy. From their observations students develop a framework allowing them to predict when they might expect to see energy conserved.

H03-03 (3:24 to 3:36 PM) | Contributed Talk | Designing Inquiry-based Physics Labs for Non-Science Majors

Presenting Author: Michael Robbins, Auburn University

Traditional introductory physics labs are frequently focused on demonstrating and reinforcing lecture concepts and yet are ineffective at these goals. Often, they are procedural in nature, removing most student autonomy. In a physics course for non-science majors, we transformed our labs from traditional procedural labs to more inquiry-based, skills-oriented labs. This transformation was done using the same lab equipment and only modifying the lab procedures. Students now determine how to create an experimental design, collect data, analyze data, and how to convey findings. The labs provide scaffolding early on, allowing students to develop each of these skills. The scaffolding is slowly faded away throughout the semester such that students must make all of the decisions involved in designing and executing an experiment by the end of the term. We found that this ultimately made students' attitudes about experimental physics more expert-like. This talk will focus on the theory and design principles for these labs so that high-school and introductory college instructors can see how to integrate experimental decision-making into their labs.

Session H04: PER & DEI I

Location: Ballroom A05 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Jayson Nissen

H04-01 (3:00 to 3:12 PM) | Contributed Talk | Using Nepantla as a Theoretical Framework in Physics Education Research

Presenting Author: Tamara Young, University of Utah

Physics identity is an essential topic in Physics Education Research (PER). Often this research examines how physics identities form for primarily white, male undergraduate students in calculus-based physics classes at Tier I institutions. Less research in PER has engaged with the experiences of marginalized populations, such as students of color, women, and members of the LGBTQIA+ community. There exists a body of work outside of PER that considers the experiences of minoritized populations in Science, Technology, Engineering, and Math (STEM). Physics students with marginalized identities navigate multiple, often conflicting identities. One theoretical framework that explores how individuals navigate opposing identities and realities is Nepantla. Here we consider how applying the theoretical framework of Nepantla to PER offers additional insight into how individuals from marginalized communities both "play the game" and "change the game." This insight can benefit both individuals and institutions that are part of the physics community.

H04-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Discrepancies in Self-identified and Perceived Masculinity in Introductory Physics Courses

Presenting Author: Yangqiuting Li, Auburn University

Additional Author | Eric Burkholder, Auburn University

Prior research has shown that gender identity is a spectrum; however, very few studies have used non-binary gender measures in physics education research. In this study, we employed a 7-point Likert scale to examine students' self-identified femininity/masculinity and their perceptions of how others perceive their femininity/masculinity in introductory physics courses. While correlations were observed between the binary gender measure and the Likert scale femininity/masculinity measure, the latter revealed greater variance in students' gender-related identity, offering the potential for new insights into gender-related issues in physics. For instance, we found that many students in the introductory physics courses perceive themselves as more masculine than they believe others view them. Moreover, women and underrepresented racial minority (URM) students are more likely than men and majority students to hold this perception. Using logistic regression and structural equation modeling, we found that gender stigma consciousness is a significant mediator of the effects of gender and URM status on the discrepancies between self-identified and perceived masculinity. Our findings indicate that the Likert scale femininity/masculinity measure could potentially deepen our understanding of gender-related issues in physics.

H04-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Supporting Minoritized Students toward a Bachelor's Degree: The Story of the Drew Science Scholars Program at MSU

Presenting Author: Rachel Henderson, Michigan State University

Additional Author | Hady Omar, Michigan State University

Additional Author | Tiana Carter, Michigan State University

Additional Author | Jerry Caldwell, Michigan State University

Additional Author | Ariel Robbins, Michigan State University

Additional Author | Angela Little, Michigan State University

The Charles Drew Science Scholars program is a STEM program that enriches a subset of students in the College of Natural Science at Michigan State University. The ultimate goal of the program is to connect students with experiences that will support them in their development as a professional in their chosen career. In this presentation, we discuss the impressive track record that the Charles Drew Science Scholars programs holds with supporting students from minoritized backgrounds in earning a Bachelor's degree in science. Overall, the program has demonstrated great success through an analysis lens of incoming preparation and graduation rates, especially for those who identify as African American/Black, Hispanic/Latinx, or Multi-Race. We highlight one element of the program, academic coaching, which directly supports their students through the required courses for completing a Bachelor's degree. Through this support structure, we see a difference in students' overall GPA for these required courses between those who are enrolled in the Charles Drew Science Scholars program and those who are enrolled in the college more broadly. These results suggest that structures such as academic coaching may be a critical element in supporting students' success toward earning a Bachelor's degree in science.

This work was supported in part by the National Science Foundation (#1742381).

H04-04 (3:36 to 3:48 PM Tuesday) | Contributed Talk | Three Axes for Expressing Disability Models and Experiences – The Cause, the Effect, and the Ability/Disability Dichotomy

Presenting Author: Daniel Oleynik, University of Central Florida

Additional Author | Constance M Doty, University of Central Florida

Additional Author | Erin M Scanlon, University of Central Florida

Additional Author | Jacquelyn J Chini, University of Central Florida

In interviews with physics students and early career physicists, we ask about their experiences with having impairments in physics culture and settings. Within this talk, we will highlight how experiences shared by participants as disabled people in physics represent clusters of models of disability. Specifically, we apply a theoretical framing of a three-dimensional disability model space, with axes defined as medical versus social (i.e., cause); tragedy versus affirmative (i.e., effect); and minority group versus universal (i.e., ability/disability dichotomy). For example, in this framework, providing accommodations is described by a cluster of the social and minority models of disability. By analyzing participants' experiences in physics through this disability framework, we aim to identify the models that underpin supportive experiences and support the development of policies and professional development for the physics community towards benefiting disabled people. Through analysis and comparison of these models and participants' narratives, we offer a discussion and possible guidelines for instructors interacting with students with disabilities as well as opportunities for those with disabilities to deconstruct their own prior experiences.

Session H05: PER into Being a Physics Educator (or LA) and Bolstering Physics Identity

Location: Ballroom A06 **Sponsor:** Committee on Research in Physics Education **Time:** 3–4 p.m.
Date: Tuesday, July 18, 2023 **Presider:** Joss Ives

H05-01 (3:00 to 3:12 PM Tuesday) | Contributed Talk | Examining the Teaching Practices of LAs in Introductory Physics Labs

Presenting Author: Samuel Engblom, University of Illinois Urbana-Champaign

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

Additional Author | Michael J Matos, University of Illinois Urbana-Champaign

Additional Author | Jackie VArgas

Undergraduate learning assistants (LAs) possess a rich set of ideas about teaching, acquired through both their training as LAs and their own prior experiences as learners. In the context of introductory physics labs, LAs draw upon these ideas when enacting teaching strategies. Studying these enacted teaching strategies can tell us much about how LAs make sense of the practice of teaching. We will present an analysis of written LA reflections on a hypothetical teaching scenario administered as part of the LA pedagogy course, with our analysis attending specifically to differences in approach between LAs based on what they notice and attend to in the scenario. Our analysis will provide insight into the common teaching strategies LAs adopt in the lab context and how these strategies align with the goals of lab instruction.

H05-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Model the Impact of Learning Assistants' PCK-Q on Students' Conceptual Learning and Critical Thinking Skills

Presenting Author: Jianlan Wang, Texas Tech University

Beth Thacker, Texas Tech University

Kyle Wipfli, Texas Tech University

Stephanie Hart, West Texas A&M University

Learning Assistants (LA) play an important role in inquiry-oriented physics instruction. They increase teacher-student ratio and provide timely support to student exploration. Questioning is an advantageous strategy for LAs to scaffold student learning and maintain their agency in knowledge construction. Unfortunately, there are few studies that measure LAs' competence of questioning or its impact to students' learning. In this study, we measured LAs' Pedagogical Content Knowledge regarding Questioning (PCK-Q) with a pre-validated written instrument. We used the instruments of Force Concept Inventory (FCI) and Critical thinking Assessment Test (CAT) to measure over 80 students' conceptual understanding and critical thinking skills at the beginning and end of an introductory course about classical mechanics. We also tracked the frequencies of interactions between students and participating LAs through the entire semester. With all the data, we built a model to describe the impact of LAs' PCK-Q on students' learning. We will also introduce our written instrument for the assessment and preparation of LAs' PCK-Q.

H05-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Access to Ideational Resources through LA Program Elements Supports Critical Physics Identity Development

Presenting Author: Xandria Quichocho, Texas State University

Additional Author | Simone Hyater-Adams

Additional Author | Eleanor W. Close, Texas State University

In our research we invite multiply-marginalized physics students—Black, Indigenous, Women of Color and LGBTQ+ women—studying physics at a Hispanic Serving Institution to participate in semi-structured interviews about their unique experiences in physics and how their social identities affect their physics identity. All students were asked about their perceptions of their physics environments, available support systems, and how they would describe a physicist. We found that participants from Texas State University described multiple positive impacts from the Physics Learning Assistant (LA) Program. We analyzed these participants' narratives using the Critical Physics Identity framework (Hyater-Adams et al., 2019) to see in what ways LA participation overlaps with the participants' racialized and/or queer experiences studying physics. We present a case study of a single participant, focused on the ways in which the LA Program provided her access to ideational resources–"aspects of an idea that impact one's connection to physics"–and how these resources supported her identity negotiation and positive physics identity development.

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

H05-04 (3:36 to 3:48 PM Tuesday) | Contributed Talk | Assessing Physics Educator Programs for Disciplinary Attentiveness

Presenting Author: Leslie Atkins, Boise State University

Faculty at Boise State University are developing an assessment to evaluate a critical aspect of physics educator preparation programs: the ability to accurately interpret and productively respond to students' ideas. In this proposed project, we build on preliminary work from mathematics education to create an instrument to assess programs for their ability to promote physics educators' disciplinary attentiveness to student ideas in physics. This work is consistent with national documents (NGSS, Framework) on secondary STEM teaching, discipline-based research literature in physics education highlighting common student ideas in introductory physics, and science education research highlighting the role of responsiveness in science teaching. In this talk, we discuss the development of the assessment and next steps in finalizing and using the assessment.

Session H06: How to Analyze and Assess When Conducting PER

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Stephanie Chasteen

H06-01 (3:00 to 3:12 PM Tuesday) | Contributed Talk | Adopting Causal Inference Methods in Quantitative Physics Education Research

Presenting Author: Vidushi Adlakha, University of Illinois Urbana-Champaign

Additional Author | Vidushi Adlakha, University of Illinois Urbana-Champaign

Quantitative causal inference techniques - commonly applied in social science, biomedical, and economics research - can benefit PER. These causal methods provide a unified framework for understanding and tackling many of the thorny challenges that arise in quantitative educational research. We will provide a brief overview of the diagrammatic approach to representing and determining appropriate quantitative analyses for causal inference. Then, we will illustrate how these methods can provide a unified framework for understanding many previously discussed issues in quantitative PER sampling and analysis. Moving forward, we hope that increased understanding and adoption of these methods can provide the basis for increased consensus and clarity on the issues surrounding causal inference in PER.

H06-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Beyond the Normalized Gain: Communicating Educational Outcomes

Presenting Author: Elaine Christman, West Virginia University

Additional Author | Paul M Miller, West Virginia University

Additional Author | John C Stewart, West Virginia University

For decades, physics education researchers have reported normalized gain on conceptual inventories as a measure of student learning and course effectiveness. However, this single metric does not capture the variation of outcomes experienced by students entering a class with varying levels of prior physics preparation, which must be considered if we seek to ensure equitable instruction for all students. In this talk, we propose methods of reporting conceptual evaluation results that more fully characterize this range of outcomes and allow researchers to make use of the natural variation within a class to compare outcomes within or across institutions as they evaluate the impact of educational interventions.

H06-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Couplet Scoring: A New Paradigm for Designing and Scoring Research-Based Assessment Instruments

Presenting Author: Michael Vignal, JILA and the University of Colorado Boulder

Additional Author | Gayle Geschwind, JILA and the University of Colorado Boulder

Additional Author | Danny Caballero, Michigan State University and the University of Oslo

Additional Author | Heather Lewandowski, JILA and the University of Colorado Boulder

Contemporary assessment instrument development often employs conventions of unidimensionality, single-construct items, and single-correct-answer items to support assessment instrument validity and reliability. While many instrument developers intentionally create multidimensional instruments, few have embraced having multi-construct items or multi-correct-answer items. In this talk, we briefly discuss the affordances and constraints of these common conventions and introduce couplet scoring, a new scoring paradigm that scores and reports results from multi-construct items multiple times, once for each of the item's constructs. We use the recently developed Survey of Physics Reasoning on Uncertainty Concepts in Experiments (SPRUCE) to demonstrate how to develop an instrument that uses couplet scoring and to highlight the features and affordances of couplet scoring.

H06-04 (3:36 to 3:48 PM Tuesday) | Contributed Talk | Finding Dimensions of (mis)Understandings on the FCI by Analyzing Wrong Responses

Presenting Author: David Pritchard, MIT

Additional Author | Aaron Adair, MIT

Additional Author | Martin Segado, MIT

Particular student misconceptions should result in patterns of wrong answers (distractors) on research-designed multiple choice instruments. To find such misconceptions, we wrote three Multidimensional Nominal (normalized) Categories (one selection/question) item response Models: MNCM (1), one showing the weight of each response on each dimension. These are the most general linear Item Response Theoretical models in which students have an ability on each dimension and each response to each question has a discrimination (weight) on each dimension as well as a difficulty. Applied to the FCI, the first dimension corresponds to "Newtonian Correct"; the second dimension differentiates between understanding Newton's 2nd law better than his 3rd ; whle the third varied among institutions but heavily involved the concept of circular impetus (the posited existence of a force along the direction of motion of an object in circular motion). These codes are available on git-hub and we are happy to share them.

(1) Javier Revuelta. Multidimensional Item Response Model for Nominal Variables. *Applied Psychological Measurement*, **38**(7):549{562, 2014

Session H07: Mentoring Students for Careers in Physics

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Zoe Buck Bracey

H07-01 (3:00 to 3:12 PM Tuesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | MCP – Mentoring for Careers in Physics

Presenting Author: Ran Yang, William & Mary

Additional Author | Chris Monahan , William & Mary

Additional Author | Jenny Carlos, William & Mary

Mentoring for Careers in Physics (MCP) at William & Mary empowers women and gender minorities facing career barriers to achieve their professional aspirations through personalized, one-on-one mentoring. Our experienced mentors provide guidance to help mentees overcome barriers and navigate the complexities of their career paths. MCP's successful pilot year in 2022, expanding in 2023 with increased participation and valuable industry connections, demonstrates its feasibility and impact. Mentee feedback shows a sense of kinship and relationship building with mentors. MCP's pairing process matches mentees and mentors based on interests, personalities, and goals for unique professional development. MCP's digital presence is growing with an active website and social media platforms. MCP is a desirable solution that benefits students, the university, alumni, and external mentors and their employers. For students in physics, MCP is a valuable resource for academic and professional success, offering guidance and support from experienced mentors. MCP also promotes alumni engagement and helps the university establish a reputation as an institution that values diversity and provides resources for student success. Mentors can develop leadership skills, gain fresh perspectives, and expand their network, while companies can recruit new employees from W&M and spark new ideas and approaches.
MCP website: https://mcp.physics.wm.edu

H07-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | The SPS Internship Program: Opening Career Pathways

Presenting Author: Mikayla Cleaver, American Institute of Physics, Society of Physics Students

Ask most students, "What can someone do with a physics degree?" Most answers will be some form of research. The SPS Internship program helps to open students' eyes to different career opportunities to them after they graduate with a physics degree. From positions in outreach, science writing, history, policy, and more, interns live and work with each other in Washington, DC, applying their skills in ways they have not before. Walk through the different programs SPS offers and meet a couple of the SPS Interns who have moved onto successful careers that use physics in some not-so-obvious ways.

H07-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Creating a Community of Peer Mentors at MIT

Presenting Author: Byron Drury, Massachusetts Institute of Technology

Effective mentorship can play a vital role in helping students thrive and persist through the challenges of becoming a physicist. This is especially true for students from underrepresented and marginalized groups, and such students often have less access to culturally responsive mentoring relationships. We report on the creation of a peer mentoring program for physics students at MIT. To date, the program has connected over 1000 undergraduate physics students with support from over 100 undergraduate, grad student, postdoc, faculty and staff mentors over the past seven semesters. Since effective mentorship is a skill which must be learned and improved through practice, we have created a pedagogy course and community of practice for peer mentors and teaching assistants. We will describe the peer mentorship program, pedagogy class, and community of practice and present preliminary evidence of the effects the program has had on mentors and mentees.

H07-04 (3:36 to 3:48 PM Tuesday) | Contributed Talk | Changing the Narrative of Who Does Physics with the STEP UP Physics Project

Presenting Author: Alma Robinson, Virginia Tech

Do you want to change the narrative that physics is done by lone geniuses? Do you want all of your students to feel like they belong in physics even if they haven't seen physicists who look like them? Over the past few years, I've explicitly discussed the underrepresentation of historically marginalized groups in physics by teaching a modified version of the STEP UP Physics Project's Women in Physics lesson. The lesson uses data to help motivate conversations about how implicit bias and cultural influences/stereotypes, rather than some inherent interest or ability of women (or other marginalized groups), impact who pursues physics. I encourage students to share their experiences related to science/math and their identity (gender/race/age/ LGBTQIA+/disability/class/background). Because some students might not feel comfortable sharing these very personal experiences in a class-wide discussion, they are also given the option to share a statement anonymously using a google form. I then read some of these statements out loud, giving voice to experiences that otherwise may have stayed silent. Each year, the class engages in an incredibly rich discussion and students reach out to thank me for giving them the space to embrace their full identity in a physics class.

Session H08: Upper Division Undergrad

Location: Ballroom A09 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Mary Bridget Kustusch

H08-01 (3:00 - 3:12 PM Tuesday) | Contributed Talk | The Formation of Physics Subfield Interests During Undergraduate Education

Presenting Author: Dina Zohrabi Alaee, Rochester Institute of Technology

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

Physics majors' interests in particular subfields of physics will influence their future career choices, but how those interests form is understudied. This has implications for inclusion because we want to ensure all students have positive opportunities to develop awareness and interest in a range of subfields. Likewise, we want to understand if students are avoiding certain paths due to negative experiences. A total of 41 physics majors participated in this study between 2020 and 2022. Our interview protocol was rooted in Social Cognitive Career Theory, which models various influences, such as outcome expectations, self-efficacy, and experiences within and outside of school. We found that students who were interested in altruistic physics subfields (e.g., medical physics, biophysics, physics education) had similar outcome expectations for wanting their work to help people and society. Whereas students who chose to pursue other subfields of physics (e.g., astrophysics, condensed matter physics) tended to emphasize outcome expectations around gaining a deeper understanding of the field and problem-solving. Our long-term goal is to develop career assessment tools that departments and researchers can use to study career decision-making processes and improve support and agency for students as they pursue the next step after college.

H08-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Lagrangian and Hamiltonian Mechanics Concept Inventory for Upper-level Undergraduate Students

Presenting Author: Guofu Ma, The Ohio State University

Additional Author | Lin Ding, The Ohio State University

Lagrangian and Hamiltonian mechanics are essential topics that connect classical physics with quantum mechanics. However, there is a lack of comprehensive concept inventory covering these topics. Previous research has either excluded this area or focused solely on the principle of least action. To fill the gap, we propose a new multiple-choice concept inventory on Lagrangian and Hamiltonian mechanics, aimed to test university students' understandings of Noether's theorem, Euler-Lagrange equation, Hamiltonian equation, Poisson brackets. Expert interviews are conducted to establish the content validity of the assessment instrument. Interviews with graduate and upper-level undergraduate students are carried out to check its face validity. Pilot testing of the assessment items will be conducted with upper-level undergraduate students by using both classical test theory and Rasch modeling.

H08-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Quickly Demonstrate the Power of Lagrangian Mechanics by Connecting Symmetry to Conservation Laws

Presenting Author: Clinton Lewis, West Valley College (retired)

The power of Lagrangian mechanics remains clear without using the mathematical tools of the calculus of variation. Using Newton's F=ma as an example, the student will quickly see the connection between the Lagrangian, the equation of motion, symmetry and conservation. A simpler approach may allow earlier introduction of these tools in the Physics curriculum.

H08-04 (3:36 to 3:48 PM Tuesday) | Contributed Talk | Radius of the Earth from Photo of Two Distant Bridges

Presenting Author: Clinton Lewis, West Valley College (retired)

This is the story of how serendipity, persistence, and a modeling approach lead to an accurate radius of the Earth. An unusual photograph through a telescope of two distant San Francisco bridges, one close, one far, shows the curvature of the Earth. The more distant bridge is clearly lower in the water of SF Bay than a Flat-Earth calculation would indicate. Three models deliver successively better results. Measurements on this photo, bridge dimensions, and a calculation results in an estimate of the radius of the Earth surprisingly accurate!

Session H09: Teaching Intro Physics for Life Sciences, Part 2

Location: Ballroom A10 **Sponsor:** Committee on Physics in Undergraduate Education **Time:** 3–4 p.m.
Date: Tuesday, July 18, 2023 **Presider:** Bruce Mason

H09-01 (3:00 to 3:12 PM) | Contributed Talk (12 Minutes) | Disconnect Between Experts' Views on the Importance of Coverage of Drag and Textbooks' Actual Coverage of Drag

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 North Carolina Chapel Hill

Additional Author | Dawn Meredith, University of New Hampshire

This work is part of a multi-institution collaboration developing a fair, valid, and reliable research-based conceptual fluids assessment, the Fluids Conceptual Evaluation (FCE). The FCE will utilize two-tier multiple-choice items covering both fluids statics and fluids dynamics. A cadre of nine experts including curriculum developers, researchers, and writers, from physics and biology, participated in a Delphi process [1] to determine the fluid dynamics constructs to be targeted by our assessment. One of those constructs deemed extremely important by the majority of the experts involves the comparison of viscous drag and pressure drag forces. Clinical interviews and a comparison of introductory texts revealed a lack of consistency in both coverage and vocabulary regarding the different types of drag forces. This talk will summarize our findings and highlight the disconnect between practitioners' and authors' views of the significance of this topic. IPLS instructors interested in serving as an FCE pilot test site should contact Project Lead Dawn Meredith.

[1] Streveler, R., Olds, B., Miller, R., and Nelson, M., "Using a Delphi Study to Identify the Most Difficult Concepts for Students to Master in Thermal and Transport Science", in Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition, American Society of Engineering Education.

H09-02 (3:12 to 3:24 PM) | Contributed Talk (12 Minutes) | Ready for Pilot Testing! Update on Fluids Conceptual Evaluation Items

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

Additional Author | James Vesenka, University of New England

Additional Author | D J Wagner, Grove City College

Additional Author | Daniel Young, University of North Carolina Chapel Hill

Additional Author | Dawn Meredith, University of New Hampshire

This project involves a collaborative effort among multiple institutions to develop the Fluids Conceptual Evaluation, a reliable, valid, and fair two-tier multiple-choice instrument covering both fluids statics and dynamics. After creating multiple Tier 1 conceptual items and studying the reasons behind students' responses, the next step is to pilot test the items and determine which ones to include in the final FCE. During this talk, we will present an overview of the FCE and its various items, along with details about the planned Pilot Test for Fall 2023. The project team is currently seeking multiple institutions that offer introductory physics courses for life science majors, with or without fluids to participate in the pilot test. If you're interested in participating in the FCE pilot test this fall, please reach out to the project lead, Dawn Meredith, at dawn.merdith@unh.edu. This project is supported by NSF project 2021273.

H09-03 (3:24 to 3:36 PM) | Contributed Talk (12 Minutes) | Lab to Study Random and Systematic Error with Glucometers

Presenting Author: Reid Mumford, Johns Hopkins University

Additional Author | Blake Laing, Southern Adventist University

We have developed a lab activity that uses over-the-counter blood glucometers to study random error and systematic error, to build a stronger intuition for basic statistical tools such as the standard deviation and the standard deviation of the mean. Using glucometers rather than rulers to introduce uncertainty has two advantages: students learn that digital instruments have uncertainty, and the use of a common medical device gives the lab a dose of realism that appeals to many of our students whose interests are in the life sciences. In this talk, we will describe the activity, our experience teaching the lab in different contexts, and our experience with sharing our resources for the first time to the Living Physics Portal.

H09-04 (3:36 to 3:48 PM) | Contributed Talk (12 Minutes) | Yoga Physics: A Holistic Pedagogical Approach to Understanding the Invisible Forces, Energy, and Waves, Influencing your Mindfulness

Presenting Author: Snehalata Kadam, WPI

During adolescence a combination of strong physical and social wellbeing is necessary for an individual's healthy lifestyle. Regular practice of yoga increases strength, flexibility, balance, improving mental wellness and focus in teenagers. My project combines yoga with an emphasis on studying the effects of internal and external forces controlling the human body. By understanding how principles of physics are incorporated in yoga, teenagers will experience a novel dimension of wellness that combines STEM facts, physical activity, and mental strength. In a pilot study, 10 teenage girls from a local high school performed various yoga poses on Force Plates to understand the ground reaction force. The force vs time data was collected over the course of 5 weeks. Our preliminary results indicates that students develop the right mechanics of posture during yoga, as measured by force plates. Students analyzed and shared the data with each another as a 'think-pair-share' discussion building a better understanding of principles of Newtonian laws, while attaining a better body-mind equilibrium. The pilot study reinforces the notion that apply basic concepts of STEM to understand the biomechanics of yoga enabling students to develop a healthy space for our body and mind.

Session H10: Effective Practices in Educational Technology II

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Andy Gavrin

H10-01 (3:00 to 3:12 PM Tuesday) | Contributed Talk | Interactive Video-Enhanced Tutorials: Student Feedback from Implementation Coupled with Online Homework

Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Kathleen Koenig, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology

Helping students develop effective problem-solving strategies is an important goal of most physics courses. To help with this need we developed a suite of 30 web-based Interactive Video-Enhanced Tutorials (IVETs – available on compadre.org/ivet), which guide students through expert-like problem-solving approaches for challenging problems involving specific topics, such as conservation of angular momentum. IVETs include video narration by a live person interspersed with branching multiple-choice questions to engage students. Feedback and hints are provided for incorrect and correct responses, much like one would provide during office hours. Our prior research shows that the IVETs are effective at helping students develop problem-solving skills, but since they are designed for out-of-class implementation, it is important that students themselves recognize the benefits of these learning tools so that they engage with them properly and transfer their learning from the IVETs to other problems on their own. This presentation will discuss results from a one-semester implementation of roughly one IVET every week coupled with students' online homework. In particular, feedback from anonymous student surveys regarding the extent to which students find the IVETs to be beneficial for helping them learn to solve problems effectively on their weekly online homework will be summarized.
Work supported by the NSF IUSE Program (DUE #1821396)

H10-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Creating and Using Relative Motion Animations by MS Power Point for College Students: An Example of TPACK

Presenting Author: MEHMET TASAR, Georgia State University - Atlanta, GA

MS Power Point is common software in use and installed in almost every computer. It can be used to create certain physics animations in a relatively simple way without knowing any coding. In this presentation I will demonstrate a series of animations about 'relative motion' that also incorporates my Pedagogical Content Knowledge (PCK) blended with my knowledge of appropriate technologies that can be put in use to enhance the quality of instruction and students' understandings and problem-solving skills. When the knowledge of technologies that can be used in education is incorporated into and blended with PCK, it becomes a novel teacher knowledge known as Technological Pedagogical Content Knowledge (TPACK). In this presentation I will also speak about the importance of TPACK in developing teaching skills and delivering effective physics instruction. I will also discuss student responses to the PPT animations I created.

H10-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Inquiry into Radioactivity (IiR) for Asynchronous Learners

Presenting Author: Michael Hull

Additional Author | Maximilian Jeidler, University of Vienna

Additional Author | Eva Holzinger, University of Vienna

Inquiry into Radioactivity (IiR) is an inquiry-based curriculum developed with NSF funding in 2010 by Andy Johnson at Black Hills State University. The first author has worked with this curriculum for the past five years, primarily in leading pre-service teachers at the University of Vienna in making modifications to the curriculum for use in Austrian high schools. This semester, he introduced several lessons from IiR to students at the University of Alaska Fairbanks in the context of the online asynchronous version of College Physics 2. As a substitute to groupwork, voices of "group members" were pre-recorded and played in videos punctuated with breaks prompting the student to input his or her own answers before proceeding. Student satisfaction was elicited after the learning module. Conceptual understanding gains about radioactivity were measured via a survey developed by the authors that was administered pre and post-instruction. We will discuss the feasibility of this approach as a substitute for inquiry-based learning in asynchronous education, and, based upon student feedback, potential directions in which such "artificial group work" might be improved going forward.

H10-04 (3:36 to 3:48 PM Tuesday) | Contributed Talk | Developing a Web-based Simulation for Orbital Maneuvers

Presenting Author: Mikolaj Konieczny, Ithaca College

Co-presenting Author | Colleen L Countryman, Ithaca College

We have developed a new web-based simulation aimed at improving the accessibility of educational tools for students learning about changing orbits in two body central force problems by identifying gaps in instructional resources for specific physics concepts. Our simulation is coded in JavaScript using the THREE.js library, enabling the creation of a 3D interactive environment. We've optimized this simulation for mainstream laptops and mobile devices. We have revised the display to provide a simplified and immersive user interface for new learners. Our simulation targets learning objectives related to Kepler's Second Law, the types of orbits, conservation of total angular momentum and mechanical energy, and the effects of impulsive orbital maneuvers on the size of the orbit and total energy of the craft. Our primary aim is to help undergraduate students build qualitative intuition around these concepts. We plan to evaluate the impact of this simulation on students' understanding and engagement with targeted concepts. Future work will test and refine this simulation to improve its effectiveness in achieving the desired learning outcomes. This presentation will cover the reasons behind the choices we've made for creating this simulation and the process we've followed to develop it.

H10-05 (3:48 to 4:00 PM Tuesday) | Contributed Talk | Seeing Virtually: Teaching E&M with Augmented Reality

Presenting Author: Matthew Anderson, San Diego State University

Additional Author | Janet Bowers, San Diego State University

Additional Author | Thoman Dustin, San Diego State University

Additional Author | India Wishart, San Diego State University

Additional Author | Luke Anderson, Seattle, WA

Additional Author | Beau Green, Altoura Inc.

We are developing augmented reality environments that are specialized for undergraduate physics education: collaborative educational spaces where students can interact with three-dimensional renderings of physics phenomena and engage with each other and instructors in real time. The scope of this project involves (1) constructing three fundamental learning spaces: electric fields, magnetic fields, and electromagnetic waves, and (2) developing research-based theory regarding how virtual reality experiences can improve students' learning gains. The spaces include dynamic graphical elements relevant to the physics phenomenon, interaction tools to modify those phenomena, a live instructor, and learning assessment measures. The students' actions in these virtual environments and their learning gains are being studied in order to optimize the design and implementation of this novel approach. Access to the environment will be inclusive because it is platform-agnostic: while the instructor may use sophisticated tools, students can join using only a tablet or smartphone. This will foster successful learning opportunities for all students, and particularly for underrepresented minorities and at-risk students. Findings will advance knowledge on embodied cognition in spatial computing learning environments by investigating the ways in which various composition elements and tasks engage students in deeper levels of visualization and conceptual understanding. Funded by NSF.

Session H11: Making Physics Labs and Apparatus More Accessible

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Nathan Powers

H11-01 (3:00 to 3:12 PM Tuesday) | Contributed Talk | Implementation of a Course-based, Authentic Learning Experience in Upper- and Lower-Division Laboratory Classes

Presenting Author: Michael Ray, California State University, Sacramento

Additional Author | Mikkel H. Jensen, California State University, Sacramento

Additional Author | Liza J. Morris, California State University, Sacramento

We designed and implemented a course-based authentic learning experience (ALE) in which upper-division students design and build instruments to monitor water quality of the American River, which runs by our campus and is important to the local ecology. Students in a lower-division, introductory course then characterize and test the instruments for eventual deployment in the river. The project bridges the upper- and lower-division classes while providing all students with a great example of how physicists can contribute to environmental and societal issues. We will discuss our first implementation of the project and its benefits to students, along with our long-term implementation plans for the ALE.
Funding provided by the National Science Foundation DOE 2012891

H11-02 (3:12 to 3:24 PM Tuesday) | Contributed Talk | Teacher Moves for Inclusive and Equitable Experiences

Presenting Author: Jessica Watts, Knowles Teacher Initaitive

Co-presenting Author | Laura Shafer, Knowles Teacher Initiative

At the heart of every physics laboratory experience are the science practices. These practices together comprise the nature of science

which scientists use to generate knowledge and an understanding of the physical world around us. Students need to gain their own experiences with these practices. Scaffolding the practices is essential for all students to be able to engage in them with fidelity so as to synthesize the complex understandings of the content which is the target of instruction. Through the use of "teacher moves," teachers can structure the laboratory experience such that it allows all students equal access to the practices and provides inclusive and equitable laboratory experiences. Through employing these "teacher moves," teachers increase access to the science practices; maintain the rigor of the tasks, and provide opportunities for all students to engage in the practices at their own level, even in groups of mixed abilities.

H11-03 (3:24 to 3:36 PM Tuesday) | Contributed Talk | Color Vision Deficiency and Teaching Electromagnetism

Presenting Author: Nathan Tompkins, Wabash College

Additional Author | Karen L Gunther, Wabash College

The colors used in educational diagrams matters. When teaching electromagnetism many introductory textbooks use red for the electric field, blue for the magnetic field, and green for the electric potential. Unfortunately, these color choices can be problematic for students with color vision deficiency (CVD), which is often incorrectly referred to as color blindness. Roughly 8% of caucasian males are affected by red/green CVD with slightly smaller percentages for other male populations, red/green CVD is far less common in women. Given the current demographics of physics students, roughly 6% of all physics majors may have red/green CVD. For these students a common electrostatic diagram, with red electric field lines and green equipotential lines, is unnecessarily confusing, and if drawn on a green chalkboard, nearly invisible. This talk will describe the problem, give demonstrations on how common diagrams may appear to those with CVD, presents a simple remedy to lessen this confusion (use blue for the electric field and red for the electric potential), and resources to help instructors gauge how their teaching materials may be seen by those with CVD.
This talk is based on the publication "Color Vision Deficiency and Teaching Electromagnetism" from *The Physics Teacher (*DOI: 10.1119/5.0049803).

Session H12: Professional Skills for PER Students: Round Tables

Location: Meeting Room 03 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Urja Nandivada

Are you a student? Come join us for a round of tabling with focused topics on professional development and skills. This is a great opportunity to meet other PER students, learn about mentoring, what it's like outside of school, and more!

Session H13: 30 Demos in 60 Minutes

Location: Meeting Room 09 **Sponsor:** AAPT **Time:** 3–4 p.m. **Date:** Tuesday, July 18, 2023 **Presider:** Wendy Adams

AWARDS: 2023 AAPT Klopsteg Memorial Lecture Award – Jeffrey Bennett

Jeffrey Bennett

Pathway to a Post-Global Warming Future — Teaching a Scary Topic with Inspiration, Not (Only) Fear

Today's students often express despair when it comes to the topic of climate change, which is unsurprising given that the media often portrays our climate future as a choice between bleak and bleaker. But it doesn't have to be that way, because if we understand the science behind global warming, then we can also see pathways to its solution. In this presentation, I'll show you how I try to approach the topic "with inspiration, not (only) fear," by providing simple ways to discuss global warming science, consequences, and solutions. In this way, students (and adults!) can begin to envision the possibility of creating a "post-global warming" future within their own lifetimes, meaning a future in which the threat of global warming will have been relegated to the history books. While much of the science will be familiar to physics teachers, I hope you will take away a few concrete ideas to help you in your own teaching.

AAPT PHYSICS EDUCATION®

Tuesday, July 18

4–5 p.m.

Ballroom A01

POSTER SESSION II:
Location: Exhibit Hall A **Sponsor:** AAPT
Time: 5:30–6:30 p.m. **Date:** Tuesday, July 18

Astro (Astronomy and Astrophysics) Posters II

A104 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Galileo's Dialogue and Paradigms in Socio-Scientific Conflicts

Presenting Author: Scott Bonham, Western Kentucky University

Socio-scientific conflicts, such as origins, climate change and pandemic response, are divisive issues involving social, cultural, and scientific facets. These conflicts shaped the emergence of modern science, most notably the debate over the Copernican model of the cosmos and Galileo's trial. Far from a simple case of "science vs. religion," that conflict (like modern ones) can be understood as a clash between distinct socio-scientific paradigms—different frameworks through which people interact and make sense of the world around them. Socio-scientific paradigms involve mutually reinforcing facets such as cultural history, social identity, epistemological beliefs, metaphysical assumptions, socially constructed knowledge, cognitive biases, and social competition over resources and power. All of these facets shape the understanding of and practice of science of the distinct communities that hold them. In this poster I will describe how I use the study of Galileo's Dialogue and the conflict surrounding it to help students develop a more sophisticated understanding of the nature of socio-scientific conflicts. The course goal is for students to develop a better understand of the nature of science and to develop scientific argumentation skills that recognize and respond to the paradigms of people who hold divergent positions.

A106 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Introducing NASA's Geospace Dynamics Constellation (GDC): How it Helps Teach Physics and How Students Can Participate.

Presenting Author: Anna DeJong, Howard Community College & NASA GSFC

Additional Author | Doug Rowland Rowland, NASA Goddard Space Flight Center

Additional Author | Jared Bell, NASA Goddard Space Flight Center

The Geospace Dynamics Constellation (GDC) is a next-generation mission that uses a constellation, or fleet, of satellites to study the Space Weather at Earth—those conditions in our near-Earth space environment that can impact human life and technology. GDC represents a highly innovative approach to investigating Earth's thermosphere and ionosphere, which are two of the highest-altitude regions of Earth's atmosphere. GDC will consist of six identical satellites orbiting at ~ 400 km altitude that will study the details of how our atmosphere changes when solar conditions change and geomagnetic storms occur. In this poster, we will introduce you to the GDC mission, and describe how it can be leveraged in your classroom to study topics like Kepler's laws, gravity, atmospheric drag, and other real world physics topics related to NASA Science.

A108 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | General Relativity as Wave Refraction

Presenting Author: Robert Close, Clark College (Retired)

The bending of light paths near massive objects such as the sun is clearly similar to ordinary refraction in an elastic medium. Many scientists have used this analogy to develop an interpretation of general relativity as a generalization of wave refraction. Some have even constructed artificial "black holes" that trap light using refraction. I will show how to derive general relativity at an undergraduate level by modeling the vacuum as a deformable medium, with light and matter consisting of vibrations in that medium. This approach not only reproduces the usual explanation of gravity as refraction, it also offers insight into the nature of the vacuum in general relativity.

A110 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Transforming General Education Online Astronomy Course

Presenting Author: Neda Naseri, Middle Tennessee State University

The redesign of the online astronomy course at MTSU offers an opportunity to improve the quality of education and enhance student engagement. The key ideas to consider when redesigning such a course, including the incorporation of interactive content, simulations, assessments, and accessibility. By implementing these elements, an online astronomy course can be transformed into a more engaging, interactive, and personalized learning experience for students, fostering critical thinking, and promoting inclusivity and equity in education.

Beyond Introductory Physics Posters II

T02 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | The Physics of Lacrosse Faceoffs: Biomechanical Insights into Wrist Injury Prevention

Presenting Author: Cole Emmanuel, Marquette University

Additional Author | Melissa Vigil, Marquette University Department of Physics

The 2020 rule change in lacrosse required changes in orientation and motion of the right wrist in the faceoff position. 50% of those playing at least 5 years have noted an increase in injury or soreness post rule change. This highlights the importance of studying the biomechanics of the updated faceoff requirements in lacrosse. This initial study was used to develop methods to observe and analyze the rotation of the wrist and stick during faceoffs. After initial evaluation of available footage online proved insufficient, lacrosse faceoff specialists at Marquette University were filmed during practices and games using 240 frames per second high-speed video and specially marked sticks. Video analysis software was then used to track rotational velocity of the stick and maximum rotation angles for the wrist. Initial findings suggest that physics-informed coaching could be used to minimize wrist injury during faceoffs. Future work will involve collecting both motion and grip-force data from faceoff specialists at the professional, college, and youth levels to further refine the techniques and gain a better understanding of the biomechanics behind faceoffs in lacrosse. This study has important implications for injury prevention and athlete performance in the sport of lacrosse at all levels.

T04 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Focus Group Analysis of Upper-Division Electromagnetic Quadrupole Tutorial

Presenting Author: Dorian Baldwin-Bott, BYU

Additional Author | Andrew Mason

Additional Author | John Colton, BYU

Despite the ubiquity of problem-solving resources available to undergraduate students in introductory physics courses, many undergraduates in upper-level physics courses continue to struggle to develop or apply an effective problem-solving framework to new material. While there are several resources available to upper-level students, these resources tend to be focused on either specific aspects of problem solving (e.g. conceptual understanding, mathematical reasoning) or specific topics within an upper-division course (e.g. electron spin in the Stern-Gerlach experiment). This poster presents preliminary work on addressing these issues by introducing a prototypical problem tutorial on quadrupole tensors presented to an upper-level electrodynamics class at BYU. It will discuss the findings of focus groups interviewed after completing the problem tutorial, and examine how this exercise improved students' problem-solving capabilities, as well as other key findings on how undergraduates develop their analytical frameworks.

T06 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Quickly Demonstrate the Power of Lagrangian Mechanics by Connecting Symmetry to Conservation Laws

Presenting Author: Clinton Lewis, West Valley College (retired)

The power of Lagrangian mechanics remains clear without using the mathematical tools of the calculus of variation. Using Newton's F=ma as an example, the student will quickly see the connection between the Lagrangian, the equation of motion, symmetry and conservation. A simpler approach may allow earlier introduction of these tools in the Physics curriculum.

T08 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Content Validation of Tasks Through Evidence from Students in Assessments Through Interviews

Presenting Author: Tyler Garcia, Kansas State University

Additional Author | Michael Freeman, University of Colorado Boulder

Additional Author | Alexander Adamson, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Additional Author | James T Laverty, Kansas State University

We are working on an assessment using evidence-centered design which we are calling the Thermal and Statistical Physics Assessment (TaSPA). To create tasks, we are using a knowledge-in-use framework that focuses on identifying the evidence we need to see in student answers to claim students are able to do science, not just know science. These "evidence statements" are the observable features students generate that show they have knowledge to complete a claim. Since these tasks are designed to elicit student's evidence towards a claim, we need to determine a way to validate the tasks based on the extensive focus towards students using evidence when solving tasks. Current literature focuses on bringing in experts to validate that the tasks align with learning performances and expected evidence of these performances. We are looking to expand on this literature by articulating a way to validate tasks that use evidence-centered design through looking at students' evidence statements. To validate TaSPA tasks, we have conducted and analyzed student think-aloud interviews in regards to them answering four free-response tasks. In these interviews we are explicitly looking for the appearance of specific evidence statements. We will report a detailed process on how we validated the tasks.

T10 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Transforming U.S. Particle Physics Education: Missing Elements in Graduate Education

Presenting Author: Erin Hansen, UC Berkeley

Additional Author | Scott Kravitz, Lawrence Berkeley National Laboratory (now at The University of Texas at Austin)

Additional Author | Vetri Velan, Lawrence Berkeley National Laboratory

Additional Author | Olivia Bitter, Fermi National Accelerator Laboratory & University of Chicago (now at Northwestern University)

Additional Author | Yining You, University of Florida (now at Bard Early College)

The pursuit of knowledge in particle physics requires constant learning: as new tools become available and new theories are developed, and physicists must search for new answers with ever-evolving methods. Formal educational systems serve as the primary training grounds for particle physicists; undergraduate and graduate school is where researchers learn most of the technical skills required for research, develop scientific problem-solving abilities, learn how to establish themselves in their field, and begin developing their career. It is unfortunate, then, that the skills gained by physicists during their formal education are often mismatched with the skills actually required for a successful career in physics. We performed a survey of the U.S. particle physics community to determine the missing elements of graduate and undergraduate education and to gauge how to bridge these gaps. This poster discusses the results of this survey, completed as part of the 2021-22 Snowmass Community Planning Exercise. We also recommend several specific community actions to improve the quality of particle physics education; the "community" here refers to physics departments, national labs, professional societies, funding agencies, and individual physicists.

T12 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Magnetic Vector Potential in Magnetostatics

Presenting Author: Vladimir Tsifrinovich, NYU Tandon School of Engineering

Magnetic vector potential is one of the most difficult concepts in the advanced undergraduate course of electricity and magnetism. In this presentation I would like to share my own approach for introduction of this concept in magnetostatics. I introduce the magnetic vector potential A as a vector integral expression which is similar the integral expression for the scalar electric potential V. I explain that the mathematical advantage of the magnetic vector potential compared to the magnetic field is that it does not contain the vector product. After that I explain the Poisson's equation for A in complete analogy with the Poisson's equation for V. Then, by direct computation, I prove that the curl of the magnetic vector potential A is the magnetic field, and the divergence of A is zero. After that I consider the magnetic vector potential for two-dimensional and one-dimensional currents. Finally, I show how to solve concrete problems on magnetic vector potential. In my experience, the approach, described in this poster, is an optimal logic way for introduction of the magnetic vector potential.

Beyond Introductory Physics: Quantum Posters II

H802 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Clicker Questions as Instructional Tools to teach Time-development of Two-state Systems

Presenting Author: Peter Hu, University of Pittsburgh

Additional Author | Yangqiuting Li, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Research-validated clicker questions as instructional tools for formative assessment are relatively easy to implement and can provide effective scaffolding when developed and implemented in a sequence. We present findings from the implementation of a research-validated Clicker Question Sequence (CQS) on student understanding of the time-development of two-state quantum systems. This study was conducted in an advanced undergraduate quantum mechanics course. The effectiveness of the CQS was determined by evaluating students' performance after traditional lecture-based instruction and comparing it to their performance after engaging with the CQS.

H804 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Investigating Transfer of Learning in an Upper-level Quantum Mechanics Course

Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Ryan T Sayer, Bemidji State University

Additional Author | Chandralekha Singh, University of Pittsburgh

Transfer of learning from one context to another is considered a hallmark of expertise. Physics education research has often found that students have great difficulty transferring learning from one context to another. We examine upper-level and graduate students' facility with questions about the interference pattern in the double-slit experiment with single photons and polarizers in various orientations placed in front of one or both slits. Answering these questions correctly in the context of the double-slit experiment requires transferring learning about concepts from the context of a tutorial on Mach-Zehnder Interferometer (MZI) with single photons and polarizers in various paths of MZI. We discuss the extent to which students who worked through the MZI tutorial were able to transfer what they learned in that context to another context involving the double-slit experiment.
Work supported by NSF

H805 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Development and Validation of an Interactive Learning Tutorial on Quantum Key Distribution

Presenting Author: Chandralekha Singh, University of Pittsburgh

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.

H806 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | 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.

H807 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | 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

We discuss an investigation that suggests that, even though Dirac notation is used extensively, many advanced undergraduate and Ph.D. students in physics have difficulty expressing the identity operator and other Hermitian operators corresponding to physical observables in Dirac notation. We first describe the difficulties students have with expressing the identity operator and other Hermitian operators corresponding to observables in Dirac notation. We then discuss how the difficulties found via written surveys and individual interviews were used as a guide in the development and validation of a Quantum Interactive Learning Tutorial (QuILT) to help students develop a good grasp of these concepts. We also discuss the effectiveness of the QuILT based on in-class evaluations.
We thank the National Science Foundation for support.

H808 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Just-in-Time Teaching and Peer Instruction Using Clickers in a Quantum Mechanics Course

Presenting Author: Chandralekha Singh, University of Pittsburgh

Additional Author | Ryan Sayer, Bemidji State University

Additional Author | Emily Marshman, Community College of Allegheny County

Just-in-Time Teaching (JiTT) is an instructional strategy involving feedback from students on pre-lecture activities in order to design in-class activities to build on the continuing feedback from students. We investigated the effectiveness of a JiTT approach, which included in-class concept tests using clickers in an upper-division quantum mechanics course. We analyzed student performance on pre-lecture reading quizzes, in-class clicker questions answered individually, and clicker questions answered after group discussion, and compared those performances with open-ended retention quizzes administered after all instructional activities on the same concepts. In general, compared to the reading quizzes, student performance improved when individual clicker questions were posed

after lectures that focused on student difficulties found via electronic feedback. The performance on the clicker questions after group discussion following individual clicker question responses also showed improvement. We discuss some possible reasons for improved performance at various stages.
We thank the National Science Foundation for support.

H810 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Educational Initiatives with the Quantum Ethics Project

Presenting Author: Josephine Meyer, University of Colorado Boulder

Additional Author | Joan E Arrow, Institute for Quantum Computing, University of Waterloo

Additional Author | Sara E Marsh

Additional Author | David Sidi, Institute for Quantum Networks

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 with the Quantum Ethics Project, 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).

H812 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Ethics Education in the Quantum Information Science Classroom: Exploring Attitudes, Barriers, and Opportunities

Presenting Author: Josephine Meyer, University of Colorado Boulder

Additional Author | Noah Finkelstein, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Quantum information science (QIS) is an emerging interdisciplinary field at the intersection of physics, computer science, electrical engineering, and mathematics leveraging the laws of quantum mechanics to circumvent classical limitations on information processing. With QIS coursework proliferating across US institutions, including at the undergraduate level, we argue that it is imperative that ethics and social responsibility be incorporated into QIS education from the beginning. We discuss ethical issues of particular relevance to QIS education that educators may wish to incorporate into their curricula. We then report on findings from focus interviews with six faculty who have taught introductory QIS courses, focusing on barriers to and opportunities for incorporation of ethics and social responsibility (ESR) into the QIS classroom. Few faculty had explicitly considered discussion of ethical issues in the classroom prior to the interview, yet instructor attitudes shifted markedly in support of incorporating ESR in the classroom as a result of the interview process itself. Taking into account faculty's perception of obstacles to discussing issues of ESR in coursework, we propose next steps toward making ESR education in the QIS classroom a reality.

DEI Posters II

I902 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Eurodivergent Student Experiences in Ungraded Classes

Presenting Author: Ana Cano, Worcester Polytechnic Institute

Additional Author | Gillian Smith, Worcester Polytechnic Institute

Additional Author | Farley Chery, Worcester Polytechnic Institute

Additional Author | Sarah Stanlick, Worcester Polytechnic Institute

Additional Author | Aarti Madan, Worcester Polytechnic Institute

Additional Author | Benjamin Pollard, Worcester Polytechnic Institute

Neurodivergent students are often underserved in physics classes, and their needs neglected when developing new pedagogy. Ungrading, the practice of de-emphasizing or removing grades as a motivation for learning, has the potential to better serve neurodivergent students in physics classrooms. However, ungrading approaches could also introduce additional barriers for these students. Our ongoing research aims to explore the impacts of ungrading on neurodivergent students, and how it differs or is in line with the impacts on neurotypical students. We conducted a series of focus groups and individual interviews with students in ungraded classes, including introductory physics, at our polytechnic institution, and identified emergent themes in the experiences of neurodivergent students. Here we present initial insights into these impacts, and offer preliminary suggestions for making ungrading most effective.

I904 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | How Student Model and Implement an Exam Corrections Assignment

Presenting Author: Kirtimaan Mohan, Michigan State University

Co-presenting Author | Katie S Hinko, Michigan State University

Additional Author | Shahnaz Masani, Michigan State University

Additional Author | Rupita S Tahsin, Michigan State University

Additional Author | Sunyoung Park, Michigan State University

Exam corrections provide an opportunity for students to not only learn from mistakes, they also encourage students' growth mindset. We constructed an intervention where we asked students of our IPLS course to design an exam correction assignment. Students had to design, discuss and come to consensus on the details of the assignment. We observed and recorded the inclusive practices that were used for the entire class to build consensus on the structure of the assignment. We report on our findings and on what students valued when constructing such an assignment.

I906 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Reflecting on What We Can Glean from Emails Sent by Students of General Physics: A Personal Perspective

Presenting Author: Mahendra Thapa, California State University Chico & Yuba College

College students often use emails to communicate with their instructors, sometimes as an informal way of holding office hours. From my perspective, emailing is seen as a "safe space" for students. This presentation aims to address the following questions: What were the main reasons behind students' emails to instructors? How did the quality and quantity of emails relate to students' academic performance in the course? Did email communication provide support for marginalized groups such as

students of color, economically disadvantaged individuals, women, and the LGBTQIA+ community? Did incorporating real-world problems into the course content affect students' communication perspectives? Data was collected and analyzed from students who took general algebra-based physics courses between spring 2018 and fall 2022. One study, mentioned in Dr. Zhu's Reflections on Education (Vol. 8, No. 1, July 2012, pp. 78-93), showed that teachers' formative feedback via email was beneficial to students and promoted their learning. Although the study had a small sample size, its primary findings will be presented. While this study focuses on introductory algebra-based physics courses, its conclusions are applicable to other disciplines as well.

I908 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | The Impact of Mentoring on the Mathematics Graduate School Application Process

Presenting Author: Danielle Maldonado, West Virginia University

Additional Author | Tim McEldowney, West Virginia University

This study sought to identify the necessary knowledge and resources for undergraduate mathematics majors to understand the mathematics graduate school admissions process, and to describe any differences in knowledge based on gender or race. It also sought to assess how mentorship in mathematics related to students' self-efficacy in the field. This study examined survey responses of students enrolled in mathematics programs at over 120 domestic universities. It found a statistically significant relationship between whether a student had someone they consider a mathematical mentor and their perceived ability to apply to graduate school, regardless of gender or race. Additionally, students with mentors reported higher levels of self-efficacy in mathematics, however, higher levels of self-efficacy did not relate to a student's knowledge about the graduate school application process.

I910 (5:30 to 6:30 PM) | Poster Presentation Traditional | How the STEP UP Physics Project Can Help You Create a Student-Ready Physics Course

Presenting Author: Alma Robinson, Virginia Tech

Do your students view physics as a hurdle in their academic career or do they connect how learning physics can help them achieve their goals? Do they think that only geniuses are successful at physics, or do they have a growth mindset toward learning physics? Creating a student-ready physics class involves more than supporting your students' math and analytical skills. By encouraging students to view themselves as capable physicists and helping them understand how the skills they learn in physics can help them pursue their career aspirations, you can empower them to take on the challenges of your physics course. In this talk, I will introduce you to the STEP UP Physics project, which provides two active-engagement lessons, one on Careers in Physics and one on Women in Physics, that confront the stereotypes of who does physics and offers concrete Everyday Actions that you can enact to help all of your students be successful in physics. These evidenced-based strategies were created to encourage women to pursue physics, but have been shown to increase the future physics intentions of students from all genders.

I912 (5:30 to 6:30 PM Tuesday) | | STEP UP: Everyday Actions Towards Equity and Inclusivity in Physics

Presenting Author: Praisy Poluan

Co-presenting Author | Kori Bowns-Kamphuis

In the U.S., there is a disparity in the number of women and other marginalized groups pursuing physics. Physics education practitioners need tools to address these inequities. STEP UP, a national community of physics educators and researchers, has developed curricula to help break down the barriers and move towards inclusivity in physics. This talk will focus on the Everyday Actions Guide and how participants can reflect on their daily practice in order to make their classrooms more equitable. Participants will learn actionable steps they can take to support equity in their instruction and in lab activities, and hear from teachers who have implemented the Everyday Actions in their classrooms.

I914 (5:30 to 6:30 PM) | Poster Presentation Traditional | The Project Synergy Program at Lewis University

Presenting Author: Joseph Kozminski, Lewis University

Additional Author | Teresa Bixby, Lewis University

Additional Author | Gina Martinez, Lewis University

Additional Author | Lauren Rentfro, Lewis University

Additional Author | Piotr Szczurek, Lewis University

Additional Author | Alec Werner, Lewis University

The Lewis University Project Synergy Program is an NSF S-STEM funded program for students with financial need planning to major in Biochemistry, Chemistry, Data Science, Engineering (Computer, Electrical, or Engineering Physics), or Physics. The goals of the program include helping the students transition smoothly to college, preparing them to engage in research, and improving their STEM identity. This poster will discuss activities done during the week-long "boot camp" before the students' first year orientation week as well as preliminary results from the data collected during the first year of the award.
This work is supported by the National Science Foundation S-STEM Award #2130429.

Educational Technology Posters II

F602 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Interactive Video-Enhanced Tutorials: Student Feedback from Implementation Coupled with Online Homework

Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Kathleen Koenig, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology

Helping students develop effective problem-solving strategies is an important goal of most physics courses. To help with this need we developed a suite of 30 web-based Interactive Video-Enhanced Tutorials (IVETs – available on compadre.org/ivet), which guide students through expert-like problem-solving approaches for challenging problems involving specific topics, such as conservation of angular momentum. IVETs include video narration by a live person interspersed with branching multiple-choice questions to engage students. Feedback and hints are provided for incorrect and correct responses, much like one would provide during office hours. Our prior research shows that the IVETs are effective at helping students develop problem-solving skills, but since they are designed for out-of-class implementation, it is important that students themselves recognize the benefits of these learning tools so that they engage with them properly and transfer their learning from the IVETs to other problems on their own. This presentation will discuss results from a one-semester implementation of roughly one IVET every week coupled with students' online homework. In particular, feedback from anonymous student surveys regarding the extent to which students find the IVETs to be beneficial for helping them learn to solve problems effectively on their weekly online homework will be summarized.

Work supported by the NSF IUSE Program (DUE #1821396)

F604 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Interactive Video-Enhanced Tutorials: Student Feedback from Implementation Coupled with Online Homework

Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Kathleen Koenig, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology

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Work supported by the NSF IUSE Program (DUE #1821396)

F608 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | A Virtual Reality Adventure in Electrostatics

Presenting Author: Michael Gallis

Additional Author | Kathryn Silverberg , Penn State Schuylkill

Additional Author | Aaron Polansky , Penn State Schuylkill

VR and Gamified activities can provide an opportunity for an entertaining exploration of challenging topics in introductory physics. The Virtual Reality Adventure in Electrostatics activity is being collaboratively developed in part as an honors project. This presentation will talk about the project development as a novel approaches to learning about electric fields and forces, and will also talk about some of the ultimate goals of the project as a learning vehicle for students in an introductory Electromagnetism course.

F610 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Expanding the Scope of Science Communication: Using Youtube for Systemic Change in Physics

Presenting Author: Fatima Abdurrahman, University of Maryland, College Park - Department of Physics

While social media is widely understood as a powerful tool for science communication, its potential may be limited by the emphasis on online content that teaches domain knowledge. Beyond the explanation of physics concepts, platforms like Youtube can facilitate the sharing of resources and pedagogical knowledge between educators, as well as the rapid communication of findings between education researchers. Over the past year, I have been experimenting with Youtube science communication by making videos that examine systemic issues in physics/astronomy higher education. In less than ten months, my channel ("Dr. Fatima") has amassed over 200,000 views and an audience of over 16,000 subscribers. Through this work, I have identified a multitude of audiences eager to watch and engage with this type of content, including prospective and current STEM students, high school and college level STEM educators, and non-STEM associated viewers who have a general interest in the field. In this roundtable discussion, I will lead a conversation framed by my experience producing content for Youtube about the aims, methods, and limitations of social media science communication. In doing so, I hope we can critically reflect on modes of communication that may be well-suited for our goals.

F612 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Learning about Physics with Augmented Reality and the MARVLS App

Presenting Author: Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

The MARVLS App is an augmented reality app for students to explore physics models of abstract or 3D concepts. Topics in the second semester of a first-year physics course were chosen for the app as there are abstract and 3D concepts that are new to students and can be difficult to understand. To use, students download the app to their smartphone or tablet, view the Merge cube through their device and observe the 3D physics model overlaid on the Merge cube. Just like holding a real object, students can move the model closer and further away and rotate the model to change their view. The App can be downloaded from the Apple and Google Play Stores by searching for MARVLS: Physics II E&M. Print the Merge Cube template from the link in the app, cut it out and tape it together. Then point the device at the cube to view the AR models. Initial results from a pilot study of students using the app in a college classroom will be presented.

F614 (5:30 to 6:30 PM) | Poster Presentation Traditional | How to Utilize the Community Coordinated Modeling Center's Hands-on Tools to Study Our Sun and Its Effects

Presenting Author: Elana Resnick, ASRC Federal/ NASA CCMC

Additional Author | Maria M Kuznetsova, NASA CCMC

Additional Author | Yihua Zheng, NASA CCMC

Additional Author | Leila Mays, NASA CCMC

Additional Author | Elon Olsson, CUA/ NASA CCMC

Additional Author | Jia Yue, CUA/ NASA CCMC

Much like Earth weather affects our life, space weather affects both life on Earth and our exploration of the universe. The Community Coordinated Modeling Center (CCMC) from NASA Goddard Space Flight Center (GSFC) presents a poster on their hands-on space weather modeling tools for formal and informal educators. The CCMC supports educational activities, such as Heliophysics and space weather summer schools, contests, research visits and exchanges. We create and maintain a wide variety of tools for space weather simulations, analysis, forecasting, and visualization. This includes tools such as the iNtegrated Space Weather Analysis System (iSWA), Database Of Notifications, Knowledge, Information (DONKI), and OpenSpace 3D visualization project. The CCMC also produces and co-produce educational modules, tutorials and other training materials. We at the CCMC offer these tools to educators to enhance their space science lessons to prepare the next generation.

F616 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Similarities Between Human and Artificial Intelligence Evaluations Applied on Engineering Students on First-Year Kinematics Learning Through Argumentation

Presenting Author: Santa Tejeda, Tecnologico de Monterrey

Additional Author | Omar Olmos Lopez, Tecnologico de Monterrey

Additional Author | Erendira Gabriela Aviles Rabanales, Tecnologico de Monterrey

Additional Author | Lilian Aurora Ochoa Ontiveros, Tecnologico de Monterrey

Additional Author | César E. García-Ortiz, Tecnologico de Monterrey

Additional Author | Jose Manuel Pardo Regueiro, Tecnologico de Monterrey

The argumentative evaluation allows for evaluating comprehension, conceptual understanding, and similarity with the answer of an expert in the field. Teachers have assessment resources, with some risk of bias. A tool, based on AI can identify relevant didactic aspects. This paper investigates how the argued responses of 244 engineering students to an acceleration problem are formed, analyzed from 1) their similarity with the response of an expert by the AI tool and 2) their level of understanding (I-IV), in the light of SOLO taxonomy, by Physics professors. The findings of this work are: 1) the tool calculated that the average percentage of response similarity with an expert is 44%, 2) the teachers reported that the prestructural (I) and relational (IV) levels of understanding obtained the highest percentage in the evaluation of the average and instantaneous acceleration, followed by the prestructural and unistructural levels in the characterization of the acceleration. The results broaden the perspective of evaluation and analysis of the conceptual understanding achieved by the students since it quantifies how much their answers are aligned with that of an expert. In this way, the use and combination of this AI tool contribute to a better understanding gaps and conceptual difficulties in first-year engineering students.

Effective Practices for Developing Scientific Thinking, Reasoning, and Decision-Making Abilities Posters II

C314 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Characterizing Students' Experiences in ISLE Courses at Rutgers - Newark

Presenting Author: Patrick Makowski, Rutgers University - Newark

Additional Author | Andrew Solomon, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Joshua Rutberg, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

The ISLE approach has two intentionalities, summarized as: i) students learn physics by thinking like physicists and ii) the way students learn physics should enhance their well being. We seek to determine to what extent we fulfilled these intentionalities by characterizing students' experiences in the ISLE-reformed courses at Rutgers - Newark. Towards the end of the Fall 2022 and Spring 2023 semesters we held three small focus groups for introductory physics students with 3-5 participants each. We transcribed and coded transcripts using codes identified in Brookes, Etkina, & Planinsic (2020) and emergent codes. Participants most frequently referenced "Epistemology," or how physics knowledge is constructed. In all course components, students developed physics knowledge using scientific abilities, rather than being told. Participants also described how they would improve aspects of the course, pointing to issues of quality control. Their ideas were thoughtful and aligned with the course design. This study highlights the importance of listening to students to improve their course experience.

Introductory Courses Posters II

C302 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Whose Afraid of Subscripts? 'Extended Subscripting' as an Organic Method of Allowing Students to Own Equation Analysis

Presenting Author: A. Tabor-Morris, Georgian Court University

Every physics teacher has students who approach them asking "which equation should I use to solve this problem" but when the teacher asks "what equation(s) have you tried" and the answer is "none - I did not know which one to try - that is why I am asking you". The reluctance of students to try equations to solve problems may stem from fear of failure or wasting their time - or perhaps more fundamentally a lack of ownership of the problem. Ownership goes beyond making problems relevant to the students' lives - it means deeply involving students in the process of choosing and populating equations. Subscripts can help both students and instructors. How so? Students using 'extended subscripting' can utilize a more free shorthand that evolves in their problem-solving process. On the other hand, teachers often are looking for the 'proper' use of equations (and subscripts) as an indication that the student is processing the problem correctly. Hence showing students how to more freely to grow their equations using extended subscripts as a first try can help bridge to a correct meaningful answer. Examples involving the laws of conservation of linear momentum, angular momentum, and energy will be showcased.

C304 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Laboratory Guides: A Third Voice in Physics Teaching

Presenting Author: Eric Schiff, Syracuse University

Co-presenting Author | Samuel M. Sampere, Syracuse University

We report on an experiment with scheduling laboratory experiences for a College Physics course. For one semester, the lab experience was scheduled before the related topics were treated in class meetings, textbook readings, and homework. Student surveys were conducted weekly to assess this approach. Results were favorable. With lab-first experiments serving to introduce some topics, students may be more receptive to mathematically rigorous learning. The messaging of putting experiments first reinforces the importance of apparatus and process in experimental science.

Lab-first scheduling frees the laboratory from service as "hands-on lecture demonstrations" or as reinforcement for material previously covered in classes and homework. It does require the development of self-contained guides to experiments including introductions to necessary concepts. We provide examples of experiments and guides. With this perspective, we suggest that lab instruction becomes an independent "third voice" in the introductory course that complements the voices of the textbook and of the instructor.

C306 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Who Is Afraid of Subscripts? "Extended Subscripting" as Organic Method of Allowing Students to Own Equation Analysis

Presenting Author: Anne Tabor-Morris, Georgain Court University

Evoking student ownership in problem-solving goes beyond making problems relevant to the students' lives - it means deeply involving students in the process of choosing and populating equations. Subscripts can help both students and instructors. How so? Students using "extended subscripting" can utilize a more free shorthand that evolves in their problem-solving process. On the other hand, teachers often are looking for the 'proper' use of equations (and subscripts) as an indication that the student is processing the problem correctly. But showing students how to more freely grow their equations using extended subscripts as a first try can help bridge to a correct and also meaningful answer. Examples involving the laws of conservation of linear momentum, angular momentum, and energy will be showcased.

C308 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Tasks for Introductory Physics Inspired by SpinLaunch

Presenting Author: Ernest Behringer, Eastern Michigan University

Additional Author | Nathan Guerra, Eastern Michigan University

Global communication networks consisting of thousands of low earth orbit satellites are being constructed, which require an increasing number of launches. SpinLaunch is a company that has designed a kinetic launcher that eliminates the traditional first stage rocket. This launcher is a rich context for several topics in introductory physics, including rotational motion, momentum, energy, fluids, and modeling motion in the presence of drag. Additionally, SpinLaunch potentially involves broader concerns about the environment and the night sky. We will describe analytical and computational exercises that help students explore these topics and concerns.

C310 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | "Adjusted" Teaching Evaluation Scores at KSU: Further Reverse Engineering the Algorithm and What It Says about Students

Presenting Author: Richard Zajac, Kansas State University Salina - Aerospace & Technology Campus

Evaluation of teachers by students is common practice. The scores from these evaluations inform decisions about reappointment, promotion and tenure. Given the wide variety of factors that influence these scores, many institutions routinely employ some numerical recipe to adjust these scores even if the exact recipe is poorly understood by the faculty in question. Prompted by a recent adjustment of my own scores that seemed anomalous, I undertook an exploration of the recipe employed at Kansas State University, which includes multiple regression analyses based on years of KSU historical data. What I found paints an insightful landscape or phase space in terms of varying student effort, interest, and students' own perception of their instructor and of their own learning. The further mapping out of this "physics of student evaluations" examines the potential usefulness of adjusted scores at any institution.

C312 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Characterizing Representational Gestures in Collaborative Sense-making of Vectors in Introductory Physics

Presenting Author: Stacy Scheuneman, University at Buffalo

Additional Author | Virginia J. Flood, University at Buffalo

Additional Author | Benedikt W. Harrer, University at Buffalo

An understanding of vectors and vector operations is crucial for success in physics, as this serves as the foundation for various essential concepts, including motion and forces. Previous research indicates that only a fraction of introductory physics students have a usable knowledge of vectors and vector operations, and that more attention should be given to how students make sense of vectors. We examined classroom video data from an introductory physics course wherein students worked collaboratively through learning activities to introduce vectors and vector operations. During these activities, students' employment of gesture as a representational mode facilitated group sensemaking. We propose a taxonomy of gestures for representing vector magnitudes, directions, initial and terminal points, and transformations. By identifying and characterizing the gestures used by students, we can gain insights into their learning processes and conceptual understanding of vectors, which can inform instructional design and teaching practices.

C316 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Investigating Student Perceptions of Relevance of Computation in an IPLS Course

Presenting Author: Kirtimaan Mohan, Michigan State University

Additional Author | Katie Hinko, Michigan State University

Additional Author | Jacob Watkins, Michigan State University

Additional Author | Nick Ivanov, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

A large majority of undergraduate students taking introductory physics are life science majors. Most of these students have little to no experience with computational modelling. Yet computational modelling is increasingly viewed as an important part of physics education and its use in physics courses has been growing. In this exploratory study, we investigate how students, particularly life science majors, perceive the relevance of computational modelling in an introductory physics course for life science (IPLS) at Michigan State University. The class integrates computational modelling activities with the use of VPython in Glowscript. Using ecological systems theory as a framework for relevance, we investigate the impact of such a curriculum on students' sense of relevance towards physics and computational modelling. Specifically, we investigate how students develop a sense of relevance of computational modelling as well as the factors that influence the same. The findings of our study will help inform us in designing a computational thread for our IPLS courses.

C318 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Lecture/Studio at USC: One Year 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. Room renovation began in Spring 2022 and the first semester of the calculus-based course went live in Fall 2022. Now that we have two semesters under our belts, we have learned a thing or two as we look toward implementing the second semester of the calculus-based course. In this poster we will evaluate the new program thus far including student and faculty perceptions and leaning gains based on FCI performance and comparison of final exam performance on select problems given both pre and post implementation.

C320 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | How To Talk about Equity In STEM Classes

Presenting Author: Abigail Daane, South Seattle College

Additional Author | Moses Rifkin, University Prep

Additional Author | Danny Doucette, North Carolina State

How can we support STEM students in discussing inequity and justice to empower them to take action? We offer the Underrepresentation Curriculum: a free, modular, teacher-created resource. Our lesson plans and supporting materials explore issues of representation, identity and systems in society and in STEM. Students apply scientific practices (asking questions, analyzing data, constructing hypotheses, and evaluating information) to explore these big ideas and take action within the context of STEM. Come to this poster to learn more and join thousands of teachers in implementing this curriculum in your own classroom!

C307 (5:30 PM to 6:30 PM) | Poster Presentation Traditional | A survey of conceptual modern physics courses in U.S. colleges and universities intended for first-year non-science majors

Presenting Author: Annie Courtemanche, Bemidji State University

Co-presenting 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 courses focused on modern physics concepts intended for 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, these courses have 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 have conducted an extensive review of the course catalogs of most major 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 typical 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.

K-12 Posters II

B202 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Incorporating Energy Generation and Environmental Justice Issues into the High School Physics Classroom

Presenting Author: Nora Paul-Schultz, John D. O'Bryant School of Math and Science

Additional Author | Kara E Gray, Seattle Pacific University

Additional Author | Rachel E Scherr, University of Washington Bothell

Energy and electricity are major concerns for communities as well as being major topics in physics learning. My colleagues and I are adapting our energy and electricity instruction to help students connect their learning to local environmental justice issues. An important goal is to help students, at a Boston Public School, understand that science is implicated in ethical decision making that affects them and their communities. In this way, we hope to better prepare students to both understand social problems as scientists and address them as citizens. In this poster, I will provide an overview of the unit we created, example lessons and projects, examples of student work and a reflection on the experience. The unit that we developed started with a conceptual background into electromagnetism and then moved into students understanding how energy was generated. Students debated which energy sources Massachusetts should increase their use of and made posters about local environmental justice issues.

B204 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Understanding Scientific Reasoning of High School Students with CMS Data

Presenting Author: Marla Glover, Purdue University

The skills of scientific reasoning cut across multiple Physics activities. Understanding and improving the ability of students to use scientific reasoning is an emphasis of the Next Generation Science Standards. The nature of reasoning skills has not been explored in particle physics with high school students. My research will determine the reasoning skills students use during activities using data from the Compact Muon Solenoid experiment and the degree to which those skills are integrated into the students' discussions.

B206 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Smartphone LiDAR Motion Mapping: the Middle School Users' Learning Experience

Presenting Author: Colleen Megowan-Romanowicz, American Modeling Teachers Association

Additional Author | Mina Johnson Glenberg, Arizona State University

Additional Author | Rebecca Vieyra, Vieyra Software

Additional Author | Chrystian Vieyra Cortes, Vieyra Software

Daniel O'Brien, Georgetown University

This poster examines the kinematics learning experiences of middle school students' who used a new free LiDAR-aided smartphone app (NSF #2114586) for embodied exploration of velocity and acceleration. This app is useful for both classrooms and distance learning contexts, and builds on our prior success with Magna-AR (NSF #1822728), a smartphone app for visualizing 3-D magnetic fields that has been downloaded by more than 500,000 users. Motion Visualizer pushes the limits of and sets the standard for LiDAR-aided augmented reality use in K12 classrooms, equipping teachers and learners with a free tool for exploring position-based STEM concepts in both formal and informal settings offering both tools for flexible exploration of motion and 9 built-challenges to help users build their understanding of graphical representations. In this study we focus on both middle schoolers' user experience and its impact on their conceptual understanding of motion.

B208 (5:30 to 6:30 PM Tuesday) | Contributed Talk (12 Minutes) | Teaching Quantum Computing in Grades 7-12: Theory, Experiment, and Application

Presenting Author: Elissa Levy, Hunter College High School

As the public's excitement over Quantum Information Science (QIS) grows, we can use this as an opportunity to expand our modern

physics instruction, in particular to integrate the discovery of basic (and utterly counterintuitive) aspects of quantum mechanics with classical computing fundamentals. Many government-sponsored grants in the US are given to QIS research (and K-12 education to support future QIS researchers) because of the scientific opportunities and because factoring large numbers quickly will pose major security threats for us all. In the summer of 2022, STEMteachersNYC developed and led a workshop on teaching quantum computing, which turned into a year-long teacher book club based on Tom Wong's Introduction to Classical and Quantum Computing textbook. This talk will share some of the story behind teaching teachers QIS and will also provide classroom-ready materials. The lesson arc for students covers binary computing (how logic gates enable computers to do math), quantum mechanics (how superposition and quantum operations work), and quantum computing (how these two parts come together). These lessons have been used in a variety of school communities across grades 7-12.

B210 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Simple Hand & Arm Demonstrations for Surprisingly Subtle Force Concepts

Presenting Author: Summer Chrisman, Dublin High School

Fool students into learning with a simple hand sequence that uses muscle memory and enhanced definitions to demonstrate and reinforce multiple force concepts: https://drive.google.com/file/d/1Lc8Cq1wnK3q6GBUx_k8X88-DcECLaJaw/view . The sequence includes five explicit ideas: the definition of force, force as a vector quantity, the cause of force, forces as a way to measure interactions, and the dual nature of interaction forces. Exploring hand-vs-hand interactions also provides students with surprisingly subtle examples that they can actually FEEL of the difference between force pairs and multiple forces on the same object, net force among a system of interconnected objects, and the relationship between net force and acceleration. Revisiting the segments as students grow their understanding helps reinforce the complex and interconnected nature of physics ideas and their application to everyday occurrences. We revisit hand-to-hand demonstrations throughout the year as they are simple and accessible ways to enhance student's understanding of all four types of friction, air resistance, impulse, energy transformation & transfer, pressure...etc. This can easily be used in middle school for basic concept retention but the subtleties require advanced (high school) reasoning.

B212 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | From Lab Reports to SciComm, Teaching Students Communication Skills

Presenting Author: Marianna Ruggerio, Auburn High School

Communication is at the core of the advancement of every field. Too often students glide through an entire academic career without being taught explicitly how to communicate. This presentation will discuss taking student end of year projects and guiding students through a multi-tier series of lessons on communication to share their projects in both written and oral formats.

Labs/Apparatus Posters II

D402 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Treatment of Statistics and Error in Introductory Physics Lab Manuals: A Comparison Study

Presenting Author: Jimmy Gonzalez Nunez, University of California, Merced

Co-presenting Author | John R Walkup, Oklahoma State University - Stillwater, OK

Many students experience their first practical application of statistics and error analysis conducting activities in their introductory, science laboratory courses (labs). During this time, they learn definitions, concepts, and skills they will use for the rest of their academic and postgraduate career. This study analyzed the use of statistical methods in introductory physics labs by comparing a collection of student lab manuals from two-year community colleges and four-year universities. Approaches to introducing statistical concepts and procedures are examined for breadth of coverage and consistency with reference to the International Organization for Standardization (ISO). Our analysis reveals substantial inconsistencies in the treatment of statistics and error among the sampled manuals for labs aimed at science and engineering students. Most notably, wide disparities surfaced in terminology and relationships, along with an absence of some topics that should warrant a concerted treatment.

D406 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | RC-Circuit Video Analysis: Demonstrating Flexible Lab Design

Presenting Author: Chris Nakamura, Saginaw Valley State University

Additional Author | Ming-Tie Huang, Saginaw Valley State University

Additional Author | Ben Keen, Saginaw Valley State University

Additional Author | John Potts, Saginaw Valley State University

Additional Author | Kavindya Senanayake, Saginaw Valley State University

Additional Author | Marian Shih, Saginaw Valley State University

In contemporary higher education, online or hybrid laboratory instruction is desirable for many students. As instructors, we know face-to-face lab instruction presents pedagogical affordances the other modalities do not, however online laboratory instruction presents access affordances that may allow some students opportunities to study physics that they might not have with only traditional face-to-face instruction. COVID-19 demonstrated that the ability to transition quickly and efficiently between face-to-face and online instruction has tremendous value. We have developed a kit-based approach to introductory physics labs that is inexpensive and can be used in either modality. In this poster we show how video analysis, a technique commonly associated with mechanics, can be combined with simple, low-cost electronics, including analog meters, to investigate the time-dependence of RC-circuits. We demonstrate principles of flexible lab design for deliberately building experiments to give good outcomes, both experimentally and pedagogically across face-to-face, online or hybrid instruction.

D410 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Facilitating Physics Education in Rural Nebraksa with Open-Source Materials and Take-Home Lab Kits

Presenting Author: Jared Daily, Mid-Plains Community College

The only thing more difficult than finding prospective physics students in rural Nebraska is providing an educational experience for them that is rooted in hands-on exploration and experimentation. Mid-Plains Community College is the only college in an area covering 18 counties and spanning over 10,000 square miles. This region is home to less than 100,000 people and over 1,000,000 cattle. On average, 8-15 students register for physics classes each semester, with roughly half of them participating remotely. Rural students often struggle in college for many reasons. Sometimes, the schools they attend are so small that they lack teachers and/or resources for higher-level math and science courses. They also have higher-than-average financial challenges coming into college. College instructors can fill in these gaps by teaching dual-credit at rural high schools remotely. The emergence of affordable all-in-one lab devices in recent years facilitate the development of a laboratory curriculum to help remote students engage in the exploratory learning process despite their location. The building and distribution of lab kits along with the use of various open-source educational materials and tools can aslo mitigate the cost barrier for these rural students.

D412 (5:30 to 6:30 PM) | Poster Presentation Traditional | A Low-cost Physical Computing, Data Processing and Analysis Platform

Presenting Author: João Andrade, Rio de Janeiro State University (UERJ)

Co-presenting Author | Alan F. Machado, Rio de Janeiro State University (UERJ)

Addressing the need for affordable and repairable laboratory apparatuses in educational settings, we present a low-cost physical computing platform encompassing data sampling, decoding, real-time monitoring and processing, based on modular and platform-agnostic technologies, mainly intended for introductory laboratory Physics courses in undegraduate education. While providing ready-made examples encompassing these roles, the system is designed so that users may leverage off-the-shelf hardware modules, popular software libraries and programming languages to modify, extend and replace its components.

D414 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Introductory Physics Home Laboratory Based on Video Analysis

Presenting Author: Farook Al-Shamali, Athabasca University

Additional Author | Martin Connors, Athabasca University

Additional Author | Lawton Shaw, Athabasca University

Advancement in video technology is currently available in the pocket of almost every student, as a component of the smartphone. When combined with free or low-cost video-analysis programs, the regular student is already equipped with the hardware and software needed to carry quality physics lab experiments at the place of their choice. At Athabasca University, we developed full home-lab component for the introductory PHYS 200 and PHYS 204 physics courses without the need for conventional lab space or traditional lab equipment. After several years of implementation and assessment of students' experience, we believe the home-lab component fulfills the expected learning outcomes.

Physics Education Research Posters II

PER304 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Leveraging Daily Journal Prompts to Capture the Complexities of Self-Efficacy: Coding Across Iterations

Presenting Author: Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

This project - an expansion of our mixed methods research design to study the development of self-efficacy - explores the differences in the daily journal prompts written across two iterations. To investigate these moments, we employed a mixed methods approach coupling the Experience Sampling Method (ESM) with daily journal reflections. The daily journal prompts were used to further explore the ESM results in order to understand how moments in students' daily life were pertained to their self-efficacy. In this work, we've developed a coding scheme that describes how each of these prompts are related to the facets of self-efficacy (e.g., domains and sources). Here, we will present the coding scheme constructed and examine how we probed into the complexity of students' self-efficacy throughout their in-the-moment experiences. The coding scheme suggests our prompts were reflective of sources and domains of self-efficacy and changed over the two iterations of data collection.

PER306 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Benefits of Skills Fluency Practice for Accuracy and Course Performance: Methods and Results

Presenting Author: Qiaoyi Liu, The Ohio State University

Additional Author | Harish Moni Prakash, The Ohio State University

Additional Author | Andrew F Heckler, The Ohio State University

A variety of knowledge and skills is generally considered as vital for answering physics questions. Meanwhile, many introductory physics instructors recognize that a large number of students, to some degree, lack the appropriate fluency in such skills. To address this issue, we developed a set of practice assignments employing the "STEM Fluency" theoretical framework. The assignments are mastery-based weekly online assignments aimed at improving fluency in knowledge and skills required across different introductory physics problems, including specific skills, such as determining the sign of work, and more general, such as trigonometry and algebra. One of two different sets of these basic skills were assigned to each lecture section in algebra-based and calculus-based introductory physics courses during the fall 2021 and spring 2022 semesters at a large public research university. We discuss methods of analysis and present some preliminary evidence of an apparently positive training effect on post-test and final exam performance, with careful attention paid to controlling for appropriate covariates such as pre-test score or performance on exam items not relevant to training. Spurious effects from differences in lecture sections are discussed, which motivates future random assignment of practice conditions across lecture sections to increase confidence in the observed effect.
This research was primarily supported by an NSF IUSE grant, award 1914709.

PER308 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | The Tentativeness and Trustworthiness of Science

Presenting Author: Jocelyn Robbins, University of Colorado Boulder

Additional Author | Bethany Wilcox, University of Colorado Boulder

This study explores how educational experiences influence students' understanding of the tentativeness and trustworthiness of science. Previous researchers created instruments to measure how an individual's educational experience impacts their understanding of the tentativeness of science and identified factors that affect trust in science. However, no studies looked into education, trust, and the tentativeness of science together. To address this relationship, we created a survey with open-ended questions and likert-style items. After distributing the survey, we used statistical hypothesis testing to determine if any correlations existed between questions and different demographics groups. Contrary to what we expected, the results found that formal collegiate education was not a significant predictor of ideas about the tentativeness and trustworthiness of science; rather, political party affiliation was the strongest predictor of an individual's responses. Further research in this area could explore the relationships of intersectional identities and the impact of different types of education.

PER310 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Extended Evaluation of the Instructional Effectiveness of Computational Exercises in Teaching General Education Astronomy Courses

Presenting Author: Raymond Zich, Illinois State University

Additional Author | James DiCaro, Illinois State University

This study explored the effectiveness of integrating computational exercises as an instructional intervention in a general education astronomy course over five semesters. Fifteen spreadsheet-based computational exercises were added to a single-semester astronomy course to complement an existing active learning curriculum. The exercises were incorporated to improve students' conceptual understanding, connect concepts with mathematics, and support prediction. Long-term assessment of these computational exercises made possible determining the effectiveness of the curriculum over a range of student cohorts and instructional modalities. The results of inclusion of the computational exercises are presented, along with examples of the computational exercises. Student performance and attitudes were measured with the TOAST, LPCI, and surveys. Assessment revealed TOAST correctness gains of up to 20%, LPCI correctness gains of up to 29%, and positive attitudes towards the computational activities. The use of computational exercises is shown to be an effective curriculum tool to improve student conceptual understanding.

PER312 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Which Basic STEM Skills do Students Choose to Practice?

Presenting Author: Idris Malik, The Ohio State University

Additional Author | Andrew Heckler, The Ohio State University

Online Practice through the "STEM Fluency" application and framework is designed to improve student accuracy and speed (fluency) in basic STEM skills. STEM Fluency can also allow students to choose which skill categories to practice. We observe trends of student category selection in a 2nd-year Intermediate Mechanics course, in the SP21, AU21, and SP22 semesters at The Ohio State University, a large public research university in the Midwest. We examine the effects of the following on students' choice of practice categories in the last assignment: students' previous accuracy and speed on each category in prior assignments, student perspectives on the difficulty and importance of each category, student performance in the course, and students' demographic identities. We use Logistic Regression models to predict student choice and see which factors are most influential. We see stronger signals of 'nonproductive' category selection, namely, students choosing categories in which they are already accurate and fast, in the SP21 and SP22 semesters compared to AU21. We longitudinally track student choice trends across the 2021-22 academic year and report on significant correlations between changes in category selection behavior and grade outcomes. We also discuss a controlled intervention meant to encourage more 'productive' selection of practice categories.

PER314 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | PhysPort Redesign

Presenting Author: Lauren Bauman, American Association of Physics Teachers

Additional Author | Adrian Madsen, American Association of Physics Teachers

Co-presenting Author | Sarah McKagan, American Association of Physics Teachers

PhysPort.org is a website that has supported physics faculty in using research-based teaching and assessment in their classes and departments since 2009. We are in the process of redesigning PhysPort based on more than a decade of research into physics faculty needs around teaching and how faculty use PhysPort. Come get a sneak preview of what's coming on the new PhysPort and offer your feedback on our updates.
This work was funded by NSF grant numbers 1726113 and 1726479.

PER316 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Considering the Implications of Communities of Transformation as a Lens into 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 | Fatima Abdurrahman, University of Maryland, College Park

The Departmental Action Leadership Institute (DALI) brings together physics faculty through sustained programming that supports them in enacting effective change practices within their local physics departments. In this poster, we present our attempt to model DALI with the Communities of Transformation (CoT) framework. CoTs are a variation on Communities of Practice that can be used to understand how groups are organized to change existing practices through challenging underlying value systems. We will share examples of how DALI aligns with the three core elements of the CoT framework; (a) challenging existing values and adopting new philosophy, (b) offering space for observing and living the new practice, and (c) networking with a community to help enact new practice. We will outline the affordances and constraints of the CoT framework and what aspects of DALI are foregrounded and backgrounded in this type of analysis. Our goal is to open a dialogue around the structure and implementation of DALI and to what extent CoT can be used to model DALI and other transformative spaces.

PER318 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Why You Should Continue to Use Normalized Gain

Presenting Author: Vincent Coletta, Loyola Marymount University

Normalized Gain G has been widely used to measure learning gains on tests like the Force Concept Inventory ever since it was introduced by Richard Hake in 1997, where G = (class av post instr score - class av pre instr score)/(100% - class av prescore). In the last few years the usefulness of normalized gain has been questioned as either being "prescore biased" or not being normally distributed. Hake used G to provide compelling evidence of the superiority of interactive engagement methods of instruction over traditional methods. We present strong evidence that normalized gains are not prescore biased and are normally distributed, and therefore should continue to be an essential way of measuring student learning in a course.

PER320 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Using Social Network Analysis in Physics Education Research

Presenting Author: Bermuda Pierre, Rutgers Univeristy

Additional Author | Geraldine Cochran, Rutgers University

Social Network Analysis (SNA) is a tool for understanding connections or social relationships within a network. There are multiple frameworks in education research that connect relationships, connections, community, and collaboration to student learning outcomes. Thus, SNA is becoming an increasingly popular tool of analysis among education researchers. We will begin this talk with a brief description of various ways that SNA has been used in prior physics education research studies. We will then discuss theoretical and conceptual frameworks that have/can be utilized in education research studies that utilize SNA. Finally, we will briefly describe an ongoing project that we are working on at Rutgers University that utilizes SNA as a method of analysis and Community Cultural Wealth as a part of the conceptual framework informing the design of the project.

PER322 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | The Use of Team-based Learning (TBL) in Providing Professional Develop-

ment to Physics Instructors.+

Presenting Author: Edgar Corpuz, Department of Physics and Astronomy, University of Texas-Rio Grande Valley

Additional Author | Natalia V Guevara, Department of Physics and Astronomy, University of Texas-Rio Grande Valley

Additional Author | Ma Aileen A Corpuz, Department of Physics and Astronomy, University of Texas-Rio Grande Valley

Additional Author | Pamela Kelley , Kelley Analytics, LLC

Our institution is currently implementing a project that provides a synergistic approach to the implementation of Team-Based Learning (TBL) in the teaching of selected physics courses with the goal of improving the quality of learning among our physics students. As an initial phase, at least 10 physics faculty members were provided professional development about the elements of TBL. The series of professional development workshops were implemented using the TBL approach where the faculty members were put in teams and were given readiness assurance tasks (pre-reading, individual readiness assurance test, group readiness assurance). They then worked as a team in completing application activities which include developing readiness assurance test items and application problems for selected topics in physics. Results show that the TBL workshops had significantly enhanced participants' TBL-related knowledge and enthusiasm about implementing TBL in their courses. Learning through practice, being able to experience first-hand how to be in a TBL class, detailed explanations, and group work were reported by the participants as the most important aspects of their workshop experience. In this presentation, we will document the benefits of using TBL in enhancing the teaching skills of physics teachers.
+This project is in part supported by NSF-DUE-2216308

PER324 (5:30 to 6:30 PM) | Poster Presentation Traditional | Effect of Basic Skills Mastery Practice on Speed and Accuracy, and Predictiveness of Grades.

Presenting Author: Harish Moni Prakash, The Ohio State University

Additional Author | Andrew F Heckler, The Ohio State University

From pre and post-tests on basic skills for students in introductory Physics courses, we find that controlling for initial accuracy, speed is on average positively but somewhat weakly associated with the Exam components of course grades. From pre to post-test, students improve in accuracy and speed on average. But we hypothesize that students who score higher initially are more likely to improve in speed than students who score low initially. We find correlational evidence to support this. We also find that for the low scoring students, slowing down is associated with bigger improvements in accuracy. This could be a signal of Speed-Accuracy Tradeoff happening for these students, and it being directly linked to their Final grades through accuracy and speed. To better understand the evolutions in accuracy and speed discussed above, we look at the impact of basic skills practice through STEM Fluency, an online mastery-based practice application. Moderation effects of STEM Fluency practice on the speed-accuracy relations found earlier and the predictiveness of speed on Course grade and Exam items are explored. This research was primarily supported by an NSF IUSE grant, award 1914709.

Physics Education Research: BFY Posters II

PER402 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | How Often Can Students Co-construct Knowledge in Quantum Mechanics?

Presenting Author: Mary Brundage, University of Pittsburgh

Additional Author | Alysa Malespina, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Collaborative learning can lead to students learning from each other and solving a physics problem correctly not only in situations in which one student knows how to solve the problem, but also when none of the students can solve the problem alone. In the latter situation, students are co-constructing knowledge that helps them solve the problem. In this study, we investigate student learning and frequency of co-construction in quantum mechanics when students work with peers during class but do not receive any feedback from the course instructor.
We thank the National Science Foundation for support.

PER404 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Instructor Expectations and Reactions Toward Written Assessment Feedback

Presenting Author: Parker Poulos, Kansas State University

Additional Author | Tyler Garcia, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | Bill Bridges, Kansas State University

Additional Author | Alexander Adamson, Kansas State University

Additional Author | Michael Freeman, University of Colorado - Boulder

Assessment feedback is most often numerical. This may help instructors assess their students' understanding, but not how their own instruction can change to support student learning. The Thermal and Statistical Physics Assessment (TaSPA) is in part aimed at filling this gap between assessment and course improvement with written, actionable feedback for instructors. The TaSPA is an end-of-course, Research-Based Assessment for upper level undergraduate thermal and statistical physics. TaSPA focuses on giving instructors the freedom to choose what is most important to assess from a given list of learning goals. Instructors receive actionable feedback in addition to numerical feedback about students' performance. The aim of this qualitative study is to explore physics instructors' reactions to this written, actionable feedback from the TaSPA. The interviews conducted in this pilot study are designed toward understanding the features of assessment feedback valued by instructors, the ways in which instructors are reacting to and processing feedback from the TaSPA, and the course changes the feedback elicits, in order to inform further development of the feedback. We will report on the results of these pilot interviews in the poster presentation.

PER406 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Using Voting Theory to Guide Assessment Feedback; A Study of Faculty Interpretation of Class Score Distributions

Presenting Author: Michael Freeman, University of Colorado Boulder

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | James T Laverty, Kansas State University

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

The usefulness of a research-based assessment to an instructor can vary widely depending on how student performance on the assessment is presented. Currently, the Thermodynamics and Statistical Physics Assessment is being developed with a novel reporting method to offer targeted course-improvement strategies based on student performance rather than numerical student scores. This novel reporting method, however, brings with it unique challenges with respect to characterizing course level performance. To address these challenges, we explore Voting Theory as a framework to assist us in understanding the implicit value judgements in how we decide on the feedback we generate for instructors. We are also currently surveying faulty perceptions of course-level categorical performance distributions to learn about trends or potential areas of consensus in how faculty interpret performance distributions, which will inform what feedback we give instructors based on their course performance.

PER410 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Photovoice in an Upper-Division Physics Capstone Project

Presenting Author: Kristin Oliver, University of Colorado Boulder

Additional Author | Victoria Borish, University of Colorado Boulder

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Additional Author | Heather J Lewandowski , University of Colorado Boulder

Photovoice is a type of participatory action research that aims to enable people to act as agents of change. Using a camera, participants take photos in response to open-ended prompts and write a short caption to accompany their photos. At the end of the photovoice process, participants engage in a focus group where they collectively determine some themes that their photos show, allowing them to co-create the research being done. We implemented the photovoice methodology in a project-based physics course in which the students partnered with a quantum company to work on a real-world project. We present here an example of how photovoice can be used in a physics course with a focus on some results from the focus group. These results demonstrate that the focus group allowed us to gain new types of information that we may not otherwise have learned, and that the students appreciated the photovoice process.

PER412 (5:30 to 6:30 PM Tuesday) | Contributed Talk (12 Minutes) | An Account of Student Instructors as Change Agents in Undergraduate Quantum

Presenting Author: Alexander Conte, University of Maryland, College Park

This presentation illustrates how student-instructors can serve as change agents in undergraduate physics courses. As an undergraduate teaching assistant in a quantum mechanics course, I co-developed and implemented a regrading process where students used solutions to evaluate their own conceptual mistakes and correct them. This process had a positive impact on students, reflected in both their grades and their attitudes towards the course. The following semester, I TAed for the course again under a new instructor who initially didn't want to retain the regrade procedure. However, a previous student and I successfully advocated its continued implementation. In this talk I discuss the regrading methods alongside anecdotal evidence of student benefits. I also summarize the development process and discuss the affordances and tensions between instructors with high or low initial buy-in towards inclusion of the innovation.

PER414 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Teaching Quantum Mechanics in an Experiential Learning and Actively Engaging Environment

Presenting Author: Mehdi Adrien Ayouz, CentraleSupélec

Additional Author | Viatcheslav Kokoouline, University of Central Florida

We developed a number of digital tools to support teaching quantum mechanics. The idea behind that is main concepts of quantum mechanics are non-intuitive to an uninitiated student due to the lack of daily experience with quantum mechanics: The basis of intuition is experience. Therefore, teaching quantum mechanics with a support of numerical experiments for all main topics of quantum mechanics appears to be essential for an efficient and quick learning process. The numerical experiments are prepared using PYTHON computer codes and a graphical interface. Students and instructors can use the graphical interface to change parameters of the suggested numerical experiments or they can download, modify and run the codes on their personal computers. Finally, a website, gathering overall numerical experiments, was designed. It can be used by universities and institutions in their different educations.

Physics Education Research: DEI Posters II

PER102 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Negative Impacts of an Unwelcoming 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 white women who are physics and astronomy 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 and astronomy. Some of their suggestions include providing mentoring for women, holding members of the department accountable, providing feedback for instructors, and training sessions.

PER104 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | How Learning Environment Predicts Students' Motivational Beliefs in Physics

Presenting Author: Sonja Cwik

Additional Author | Chandralekha Singh

Societal stereotypes and biases pertaining to who belongs in physics and who can excel in physics can impact motivational beliefs, e.g., of women and racial and ethnic minority students in physics courses. This study investigates how the learning environment predicts male and female students' motivational beliefs including physics self-efficacy, interest, and identity at the end of year long (spanning two-semester) algebra-based introductory physics courses. These were courses at a large university in the US taken primarily by biological science majors many of whom are interested in health professions. Although women are not underrepresented in these physics courses, societal stereotypes and biases internalized by female students over their lifetime can still impact their motivational beliefs about physics. Our findings show gender gap in motivational beliefs favoring men. These findings can be useful to provide support and create an equitable and inclusive learning environment to help all students excel in these courses.

PER106 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | The Impact of Perceived Recognition by Physics Instructors on Women's Self-efficacy and Interest

Presenting Author: Yangqiuting Li, Auburn University

Additional Author | Chandralekha Singh, University of Pittsburgh

Prior research suggests that students' domain related self-efficacy and interest play an important role in their major and career decisions as well as their retention and persistence in STEM fields. In this study, we analyzed data from individual interviews with 38 female students to investigate their learning experiences in physics courses in order to obtain a qualitative understanding of the factors that shape their self-efficacy and interest. We find that female students' negative and positive perceived recognition from instructors and teaching assistants (TAs) greatly influenced their self-efficacy and interest and even impacted their desire to persist in STEM majors. We categorize different types of perceived recognition that women reported in our interviews and how they influenced them. These findings can help physics educators reflect on their interactions with students in order to contemplate ways to provide positive recognition and validation to their students. Our research suggests that it is important for instructors and TAs to realize that they have responsibility to intentionally develop an inclusive and equitable learning environment in which all students feel appropriately recognized and feel safe to express themselves and learn from each other.

PER108 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Grappling with the Dominant Narrative of Physics: Teachers Rethink Colonial Roots Together to Reshape Classrooms

Presenting Author: Delwrick Nanthou, South Seattle College

Additional Author | Ahmed Gumale, South Seattle College

Co-presenting Author | Abigail R Daane, South Seattle College

Additional Author | Michelle N Brown, Penn State University

Additional Author | Clausell Mathis, Michigan State University

The colonial roots of science dominate the narrative of physics learning and research. While many acknowledge that physics curricula does not support students from nondominant groups, it has remained largely unchanged. A group of teachers voluntarily met remotely each month to question how one might decolonize a physics classroom. We asked teachers to share how their conceptions of self, others, knowledge, and pedagogy shifted after participating in the group for two years. We found that teachers describe being bound by systemic aspects of their teaching environment (e.g., class size, standards, SES, etc.). However, within those constraints, each teacher felt empowered to push back by reshaping classroom content. Findings show that as a result of their time together, teachers reframed and added content to move towards a more equitable physics education.

PER110 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | A Partnership Profile Template for Two- and Four-Year Colleges

Presenting Author: Camila Monsalve, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

The PROSPECT S-STEM hub is researching partnerships between two-year colleges (2YC) and four-year colleges (4YC) that are designed to support transfer students. Before conducting a site visit to a 2YC and 4YC to observe their partnership, we created a partnership profile template (PT) that is intended to communicate back the noticings and wonders in an equitable manner. Also, the PT is intended to be collaboratively constructed by the research team because we all observed different aspects of the partnership. In this poster presentation we will describe how the template questions were divided into different sections and each section was accompanied by a motivation. We will discuss how the sections were motivated by Amey at al. (2010) partnership models, Gutiérrez (2012) & Yosso (2005) equitable orientation to student's success and how we incorporated thinking from Battacharya's (2009) approach for an equitable research design.

PER112 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | The Effect of the Inclusiveness of Learning Environment on Students' Physics Motivational Beliefs

Presenting Author: Yangqiuting Li, Auburn University

Additional Author | Chandralekha Singh, University of Pittsburgh

Research suggests that students' self-efficacy, interest and identity in physics can influence their learning, performance and career decisions. However, there are few studies focusing on how inclusiveness of learning environment shapes these motivational beliefs of women and men. Therefore, we conducted a study to investigate how students' perception of the inclusiveness of learning environment (including sense of belonging, peer interaction and perceived recognition) predicts students' physics self-efficacy, interest and identity in a calculus-based introductory physics course. Findings can be useful in creating equitable and inclusive learning environments in which all students can thrive. We thank the National Science Foundation for support.

PER114 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | How to Objectively Measure the Effectiveness of your Teaching

Presenting Author: Vincent Coletta, Loyola Marymount University

How can we know just how effective our teaching is? What about students' opinions, as reported on Student Evaluations of Teaching (SETs)? Rresearch shows that SET scores are not correleated with effectiveness of teaching. How about your student scores on standardized exams like the Force Concept Inventory (FCI)? Looks promising at first until you realizze that your students' gains on the FCI depend more on their thinking skills than on what you do for them. But there is a way you can use these scores as a measure of your effectiveness: 1) Use normalized gains G (postscore - prescore)/(100% - prescore). 2) Give students the Lawson Test of Scientific Reasoning Ability. 3) Compare class average G with other classes having a similar Lawson score. The figure I provide shows how FCI normalized gain and Lawson scores are correlated. The data displayed in the graph is derived from 1432 individual scores. Each data point is an average of 65 individual student scores, a reasonable substitute for class average scores. Compare your average FCI G with G for a point on the graph with the same Lawson score as your average score. This kind of analysis has guided me & led to improved gains.

Physics Education Research: Intro Courses Posters II

PER202 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Framework for Unpacking Students' Experiences in Introductory Physics

Presenting Author: Ellen Ouellette, University of Illinois Urbana-Champaign

Co-presenting Author | Sarat Lewsirirat, University of Illinois Urbana-Champaign

Additional Author | Ryan Biju Sebastian, University of Illinois Urbana-Champaign

Additional Author | Christina Krist, University of Illinois Urbana-Champaign

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

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

Course structures – which encompass curriculum materials and activities, how this curriculum is enacted, and how students are assessed – impact students' learning, beliefs about themselves as learners, and motivation. As part of an effort to redesign course structures to increase student success in introductory physics at the University of Illinois, we conducted 30 approximately 1-hour, semi-structured interviews with introductory physics students to investigate their experiences with course components. We observe that students typically describe their interactions with course features in terms of four major functions: defining learning tasks students are asked to perform, supporting collaboration, providing opportunities for feedback and determining grades. Further, we find that the ways students experience the functions of the various course components depend both on the design of the component's particular features and on the students' motivation, beliefs, and emotions. Providing examples of how students' experiences arise out of interaction between their own motivation, beliefs, and emotions and specific course structures, we propose that continued research in this area can uncover useful design principles for fostering student success and well-being.

PER206 (5:30 to 6:30 PM) | 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 three 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 three CSEM questions that remain challenging for many upper-level and graduate students.

PER208 (5:30 to 6:30 PM Tuesday) | Poster Roundtable | Cognitive Diagnostic Computerized Adaptive Tests with the LASSO Platform

Presenting Author: Jayson Nissen, Nissen Education Research and Design

Additional Author | Phuong-Vy Le, Iowa State University

Additional Author | Ben Van Dusen, Iowa State University

Additional Author | Xiuxiu Tang, Purdue University

Additional Author | Yuxuai Zhang, Purdue University

Additional Author | Amirreza Mehrabi, Purdue University

We are creating a new assessment that provides instructors with actionable information about student skills and knowledge central to succeeding in introductory physics courses. This Cognitive Diagnostic Computerized Adaptive Test (CD-CAT) assesses a student's development on learning objectives selected by the instructor. We began by building the CD-CAT on existing data from research-based assessments collected with the LASSO platform. Using item response theory and cognitive diagnostic models, we estimated three-parameter logistic models and item fit statistics to evaluate model fit statistics, evaluate our q-matrix, and estimate DINA model item parameters. The initial results show good item psychometrics and q-matrix fit. This indicates that CD-CAT can provide a reliable and valid measure of learning objectives for introductory mechanics courses. The CD-CAT will be available for instructors to use through the LASSO platform in the Fall of 2023.

PER210 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Exploring Connections between Collaborative Assessments and students' Self-Efficacy

Presenting Author: Ting Chia Chen, San Jose State University

Additional Author | Clare Nguyen, San Jose State University

Co-presenting Author | Cassandra A. Paul, San Jose State University

Collaborative learning has shown to be effective in comparison to traditional lecturing. Peer-based collaborative assessments aim to bridge the gap between instruction and assessments in science education. However, little is known on the impact of collaborative assessments on students' self-efficacy. Collaborative assessments provide opportunities for students to exchange ideas and conceptualize science content, potentially producing a positive impact on students' test performance and confidence in science. We investigate this connection through interviews with students about their experiences with collaborative assessments that allow for instructor feedback and incorporate multiple attempts as essential components of the assessment process. We examine the changes of students' perceived self-efficacy after participating in collaborative assessments in introductory physics and chemistry courses. The findings of this study inform science education practices and contribute to the understanding of the role of collaborative assessments in enhancing students' learning experiences and perceived self-efficacy.

PER212 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Standards-based Grading in the Introductory Physics Classrooms

Presenting Author: Adria Updike, Roger Williams University

Standards-based grading was utilized in four introductory calculus-based physics classes. Students were given essentially unlimited attempts at reassessment of the standards and had until the end of each semester to achieve the standards. Data collected includes the number of reassessment attempts by student and standard as well as the amount of time taken by each student to achieve the standards. Analysis of the data finds a moderate negative correlation between the amount of time taken by students to achieve the standards and the number of standards the student ultimately achieved (directly proportional to course grade), suggesting that setting regular deadlines throughout the semester for reassessment would be a best practice for this pedagogy.

PER214 (5:30 to 6:30 PM) | Poster Presentation Traditional | Development of Physics Affinity in Introductory Physics for Life Science Students Across Three Institutions

Presenting Author: Angelina Tjia, Swarthmore College

Additional Author | Drake Roth, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Lili Cui, University of Maryland Baltimore County

Additional Author | Alfredo Sanchez, University of Delaware

Additional Author | Benjamin D Geller, Swarthmore College

Previous work has found that at one institution, life science students' evaluation of the value and relevance of studying physics increases after taking a year-long introductory physics course that has been reformed to highlight connections between physics and the life sciences; furthermore, such gains persist for at least a year or more after Instruction. As a first step toward determining the generalizability of this previous work, we report on the development of what we call "physics affinity" — student self-efficacy, interest, achievement goals, and views about the relevance of physics — among introductory physics for life science students at three different institutions. To begin to interpret our findings, we compare the three course environments and the three approaches to incorporating life science connections. We also report preliminary results from triangulation of survey results with student written reflections and case study interviews from the institution where the original results were obtained.

PER216 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Methodologies in Assessing Student Engagement in Introductory Physics for Life Sciences

Presenting Author: Stephen Hackler, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Benjamin D Geller, Swarthmore College

Previous work studying the sources of student engagement in introductory physics for life science courses have revealed that such engagement is the product of numerous factors, including instructor messaging, course policies, and assessment design. This work made use of both quantitative (completion of assessments, questionnaire responses, etc.) and qualitative data (student interviews, journal prompts, open-ended questionnaires, etc.). In the next stages of our work, we hope to understand a more detailed mechanism by which our course achieves its outcomes. To do this, we examine the specific methodologies that we currently use to explore students' engagement pathways and refine said methodologies to better understand how the course elements produce the observed engagement pathways. Such findings will shed light on the potential generalizability of current methods and findings, providing a foundation for other institutions looking to support similar engagement pathways for their students. We present an overview of the techniques we have used to gather data for this work and our plans for revising and updating these methodologies for future work in introductory physics for life science courses.

Two Year Colleges Posters II

E502 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Happy Birthday, OPTYCs! A One Year Update

Presenting Author: Kristine Lui, AAPT-OPTYCs

Additional Author | Dwain Desbien, Estrella Mountain Community College

Additional Author | Sherry Savrda, AAPT-OPTYCs

OPTYCs, The Organization for Physics at Two-Year Colleges, celebrates its one-year anniversary on July 1st, 2023. In this poster, we present: an overview of our activities so far, some preliminary evaluation data, and plans for the future. This material is based upon work supported by the National Science Foundation under Grant No. 2212807.

E504 (5:30 to 6:30 PM Tuesday) | Poster Presentation Traditional | Continuing Professional Development Workshop Program

Presenting Author: Thomas O'Kuma, Lee College

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

Co-presenting Author | Kristine P.H. Lui, 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 workshops that have already occurred, workshops at the current meeting, future workshops, and the current tandem meeting in Sacramento. We will also invite TYC physics colleagues to submit ideas for workshop content. OPTYCs is supported by NSF-DUE-2212807.

E506 (5:30 to 6:30 PM) | Poster Presentation Traditional | The OPTYCs PER-Interest group: A Progress Report

Presenting Author: Karim Diff, Santa Fe College

Additional Author | Sherry Savrda, Seminole State College

Additional Author | Glenda Denicolo, Suffolk County Community College

Additional Author | Anthony Escuardo, Harold Washington College, City Colleges of Chicago

The mission of the PER-Interest group within OPTYCs is to strengthen Physics Education Research (PER) knowledge and engagement within the physics Two-Year College (TYC) community and to promote and support work collaborations in PER. In this poster we present an overview of the events the group has organized during the 2022-2023 academic year. We started with journal club meetings during the fall semester. Important, recent articles were selected by the group coordinators for a short presentation followed by an open discussion with the meeting participants. During the spring term, the format shifted to panel discussions and workshops. Speakers were invited to discuss (a) the history of the TYC contributions to PER (b) What PERC is about and how TYC faculty can contribute to it (c) The most popular assessment tools used for mechanics and electromagnetism in introductory courses. A final workshop guided TYC instructors through the process of uploading and analyzing FCI data on PhysPort's Data Explorer. The PER-Interest group also launched a YouTube channel and a newsletter that will be presented in a separate poster. All these activities were conducted in a virtual format through Zoom.
OPTYCs is supported by NSF-DUE-2212807.

Session I01: Effective Practices in K-12, Part 3

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Duane Merrell

I01-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Revisiting the Demonstration Framework

Presenting Author: Patrick Morgan, University of Massachusetts Amherst

Back in 2018, I presented on the Demonstration Framework I developed using three years of research into public outreach and engagement work at Michigan State University. Since then, the Demonstration Framework has further adapted and shifted to the changing climate of public education and engagement, in no small part due to the pandemic. This presentation will briefly revisit the original Demonstration Framework, then focus on the changes it has undergone in the last five years to adapt in a transitioning landscape. These changes primarily are in regard to the online/remote shift in the pandemic, as well as from more recent research into educational pedagogy.

I01-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Shifts in Student Support Structures from High School to College Engineering Programs: A Longitudinal, Qualitative Study

Presenting Author: Devyn Shafer, University of Illinois Urbana-Champaign

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

Over the course of two academic years, we collected interviews from aspiring engineers throughout their senior year of high school and freshman year of college. In particular, we have traced the support systems accessed by these students at various points in their academic journey and how they surmounted various challenges along the way. Furthermore, we spent hours in the students' high school environments, observing classes and interviewing teachers, principals, and counselors in addition to the students themselves to gain a better understanding of the context in which these students learned before transitioning to college. In this talk, we will share some of the insights we have gained from our longitudinal, qualitative study.

I01-03 (9:24 to 9:36 AM) | Contributed Talk (12 Minutes) | STEP UP: Careers in Physics and How Physics is Done

Presenting Author: Elissa Levy, Hunter College High School

Members of historically oppressed groups in the United States are systematically underrepresented in physics. In the STEP UP lessons, students learn how this phenomenon is the product of our culture. And as Hazari et al (2013) concluded, when students discuss these issues productively, underrepresented individuals are more likely to choose a physics major. These conversations belong in our classrooms. Students need a visceral sense of what it feels like to do science today, both in the day-to-day analysis, ideating, and writing and also in the inherent navigation of social situations and unwritten cultural rules. This talk will cover the STEP UP Careers in Physics lesson, which gives students an inspiring (and customized to their interests) set of role models who work in myriad sub-disciplines of physics. The talk will also address opportunities to extend the STEP UP lessons based on student interest, to show other ways that the day-to-day life of physics can become tangible to students: mentorship, guest speakers, personal narratives, and imagined scenarios.

Hazari, et al, 2013: https://journals.aps.org/prper/abstract/10.1103/PhysRevSTPER.9.020115

Session I02: Innovations in Teaching Astronomy

Location: Ballroom A03 **Sponsor:** Committee on Space Science and Astronomy **Time:** 9–10 a.m.
Date: Wednesday, July 19, 2023 **Presider:** Kevin Lee

I02-01 (9:00 to 9:24 AM Wednesday) | | Turning Data Into Conclusions: Adventures in Teaching Statistical Inference for Astrophysics

Presenting Author: Adam Mantz, Stanford University

Additional Author | Phil Marshal, SLAC National Accelerator Laboratory

Astronomy and physics are driven by observation and experiment. Yet it's extremely rare for our (astro)physics graduate students to arrive having been exposed to the practice of principled statistical inference - the key process of transforming data into conclusions, at the heart of modern research - in any depth. Most often, their exposure is limited to brief practical lessons in an advanced lab course, where the greater emphasis is understandably on data acquisition and analysis is something of an afterthought. In this talk, I will describe a course developed at Stanford, aimed at beginning grad students but also attracting some undergrads, that attempts to fill this gap. Our goal is to provide students with the understanding and practice needed to confidently apply the methods of principled inference in their own research. Over time, the course has evolved into a flipped-classroom format, where assessment is almost entirely based on completing tutorials - guided applications using to real (or realistic) data in Python-language Jupyter notebooks. All of our materials, including tutorials and course notes, are available at kipac.github.io/StatisticalMethods/ .

I02-02 (9:24 to 9:48 Wednesday) | | The Exploratorium's Experiments in Producing Online ASTRONOMY

Presenting Author: Robert Semper, Exploratorium

The Exploratorium was founded in 1969 to provide the public with engaging physical learning experiences about the world around them. Over the years it 's staff has designed and built hundreds of interactive exhibits that provide opportunities to learn through experimenting with natural and human phenomena. With the development of the public internet in the early 1990's, it began to explore ways to extend the museum's offerings to an online community. In 1993 it used its museum design sensibilities to develop an engaging online presence becoming one of the first museums to host a website. Over the years it has developed online interactive exhibits, produced webcasts about current science including astronomical events, originated online fieldtrips to science laboratories around the world including from Antarctica, CERN, Hubble Space Telescope and oceanographic research ships, created online classroom teaching resources based on Exploratorium exhibits and produced virtual teacher education workshops. Starting in 1998, in partnership with NASA, it has produced live media coverage of total solar eclipses from all over the world. The presentation will discuss our plans for covering upcoming solar eclipses and explore the potential of using online technology to extend a museum to a world far beyond its walls.

Session I04: PER & DEI II

Location: Ballroom A05 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Brianne Gutmann

I04-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Learning to Disembody in Physics

Presenting Author: Tra Huynh, Western Washington University

Additional Author | Amy D Robertson, Seattle Pacific University

Additional Author | Lauren Bauman, University of Washington

| Déana Scipio, Islandwood Graduate Program

Additional Author | Sarah Stella, Urban Indian Heath Institute

| Tali Hairston, Equitable Development LLC

In this talk, we will present a short exchange collected from an introductory physics class in which a group of students works with a Learning Assistant to make sense of rotational motion. In the exchange, students express disbelief about the outcome of an experiment, as it contradicts their sensory experiences. Although they continue to feel unconvinced, they accept the physics explanations offered by their LA, who encourages them to trust physics over their bodily experiences. As we study students' learning experiences, we are interested in answering the question: What is it about the physics learning environment that shapes their willingness to disembody?

This material is based upon work supported by National Science Foundation Grant No. 2201929 and No. 2201930

I04-02 (9:12 to 9:24 AM C) | Contributed Talk | Benefits of Skills Fluency Practice for Accuracy and Course Performance

Presenting Author: Qiaoyi Liu, The Ohio State University

Additional Author | Harish Moni Prakash, The Ohio State University

Additional Author | Andrew F Heckler, The Ohio State University

A variety of knowledge and skills is generally considered as vital for answering physics questions. Meanwhile, many introductory physics instructors recognize that a large number of students, to some degree, lack the appropriate fluency in such skills. To address this issue, we developed a set of practice assignments employing the "STEM Fluency" theoretical framework. The assignments are mastery-based weekly online assignments aimed at improving fluency in knowledge and skills required across different introductory physics problems, including specific skills, such as determining the sign of work, and more general, such as trigonometry and algebra. One of two different sets of these basic skills were assigned to each lecture section in algebra-based and calculus-based introductory physics courses during the fall 2021 and spring 2022 semesters at a large public research university. We present some preliminary evidence of an apparently positive training effect on post-test and final exam performance, with careful attention paid to controlling for appropriate covariates such as pre-test score or performance on exam items not relevant to training. Spurious effects from differences in lecture sections are discussed, which motivates future random assignment of practice conditions across lecture sections to increase confidence in the observed effect.

This research was primarily supported by an NSF IUSE grant, award 1914709.

I04-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | Students Who Repeat College Algebra-based Introductory Physics Courses

Presenting Author: Lisabeth Santana, University of Pittsburgh

Additional Author | Alysa Malespina, University of Pittsburgh

Additional Author | Sonja Cwik, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

We analyze institutional data from large introductory algebra-based physics courses at a large public research university in which the majority of students are biological science majors. A large percentage of these students are on a pre-health professional track in which they aspire to become health professionals. Two introductory physics courses are required for these students and they are often considered "weed out" courses, meaning low performance in these courses can hinder students' long term career goal achievement. In particular, these courses can act as gatekeepers for many students, particularly those who come from less privileged backgrounds, e.g., ethnic and racial minority (ERM) students, who may not have had access to the best educational resources prior to college. In these physics courses, many students who do not perform to their satisfaction the first time repeat, particularly if they aspire to become health professionals. In this investigation we analyze the performance of students from different demographic groups who repeated the first introductory algebra-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 these algebra-based physics courses which are pivotal for accomplishing their long-term career goals.

I04-04 (9:36 to 9:48 AM Wednesday) | Contributed Talk | Student Affective Experiences in Introductory Physics for Life Sciences

Presenting Author: Drake Roth, Swarthmore College

Additional Author | Angelina Tjia, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Kya Butterfield, Swarthmore College

Additional Author | Stephen Hackler, Swarthmore College

Additional Author | Benjamin D Geller, Swarthmore College

Both instructor experience and an increasing amount of physics education research points to the importance of affective experiences in student learning. In order to develop methods of documenting student affective experiences, we collected brief weekly reflections in which introductory physics for life science students wrote about their sense of engagement and confidence in their ability to achieve their goals. We report preliminary findings about the connections between the experiences reported in these reflections and the curricular, pedagogical, and relational elements of the course. In particular, we describe how experiences vary by student seniority and high school physics background. We also expand upon what is learned from the reflections by triangulating with surveys and case study interviews conducted with a small subset of the class. This work is a first step toward better understanding how introductory physics for life science courses can be designed to positively shape the student affective experience.

Session I05: PER & Assessment Ideas IV

Location: Ballroom A06 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Gina Passante

I05-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Multi-Semester Assessment of the Effects of Modified Electric Field Diagrams on Student Interpretation

Presenting Author: Raymond Zich, Illinois State University

The effects of visually modifying traditional electric field diagrams on student interpretation were studied over five semesters. Electric field diagrams are often drawn with a uniform line thickness and color. The electric field diagrams were modified with variations in line thickness, line continuity, and arrow shape to indicate the magnitude and direction of the electric field. These modifications were done consistent with theories of visual attention and grounded cognition, to communicate the electric field strength and direction using the students' ability to perceive line variations and arrow styles. Students were randomly assigned traditional or modified diagrams and asked to rank electric field strength and direction for points on the diagrams. Results show correctness gains ranking magnitude of 12.3% and gains identifying direction 7% for using the modified diagrams. Modified diagrams yielded overall correctness gains of 10% over the traditional diagrams.

I05-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Context Dependence of the Motion Implies Active Forces Misconception

Presenting Author: Christopher Wheatley, Physics

Physics education research has a long history of building tools to identify a wide range of common misconceptions in Newtonian mechanics. There is a need for a set of tools that provide additional insight into individual misconceptions to allow instruction to be tailored to help students move to Newtonian reasoning. This project examines the common misconception that an object in motion must have a force in the direction of its motion. Students were more likely to demonstrate this misconception after being prompted by the language "force in the direction of motion" in a multiple-choice format, suggesting that either hand-drawn free-body-diagrams or a problem-specific, named force should be used instead. Students also demonstrated this misconception more often in certain contexts than others. Studying the context dependence of this misconception should help disentangle whether students are only choosing "force in the direction of motion" because it happens to coincide with the net force on an object.

I05-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | Using Voting Theory to Guide Assessment Feedback; A Study of Faculty Interpretation of Class Score Distributions

Presenting Author: Michael Freeman, University of Colorado Boulder

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | James T Laverty, Kansas State University

Additional Author | Bethany R Wilcox, University of Colorado Boulder

The usefulness of a research-based assessment to an instructor can vary widely depending on how student performance on the assessment is presented. Currently, the Thermodynamics and Statistical Physics Assessment is being developed with a novel reporting method to offer targeted course-improvement strategies based on student performance rather than numerical student scores. This novel reporting method, however, brings with it unique challenges with respect to characterizing course level performance. To address these challenges, we explore Voting Theory as a framework to assist us in understanding the implicit value judgements in how we decide on the feedback we generate for instructors. We are also currently surveying faulty perceptions of course-level categorical performance distributions to learn about trends or potential areas of consensus in how faculty interpret performance distributions, which will inform what feedback we give instructors based on their course performance.

I05-04 (9:36 to 9:48 AM Wednesday) | Contributed Talk | Machine Learning Analysis of Physics Instructor Evaluations

Presenting Author: Karland Kilian, UW-Platteville, 1 University Plaza, Platteville, WI 53818

Additional Author | Afzal Upal, Department of Computer Science and Software Engineering, UW-Platteville, 1 University Plaza, Platteville, WI 53818

To the best of our knowledge, machine-learning (ML) methods have not been used to analyze student evaluations of college instructors to learn which factors are predictive of instructor ratings. One of us (KAK) created a dataset from 551 evaluations by students in three different levels of physics classes: algebra-based one-semester survey for industrial studies majors, first-semester calculus-based physics for engineers, and second-semester calculus-based physics for engineers (KAK had been a lecturer in the Department of Engineering Physics at UW-Platteville). The students rated him on five questions, gave an overall rating, and could also choose to provide freeform comments. The overall rating was transformed into a binary attribute of "good/bad" instructor. The Python natural-language toolkit (NLTK) was used to extract distinct words and N-grams (N= 2 to 6) from the comments. The WEKA suite of machine learning tools was applied to the resulting dataset. We discuss the results with a focus on which of the five questions most closely tracked a positive instructor evaluation, and which words/N-grams from student comments best predicted the good/bad instructor ratings.

Session I06: PER into Student Understanding (including assessment instruments)

Location: Ballroom A07 **Sponsor:** Committee on Research in Physics Education
Time: 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Karen Cummings

I06-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Preliminary Findings from the ACORN Physics Tutorials

Presenting Author: Lauren Bauman, University of Washington - Seattle

Additional Author | Lisa M. Goodhew, Seattle Pacific University

Additional Author | Al Snow, University of Washington - Seattle

Additional Author | Amy D. Robertson, Seattle Pacific University

Conceptual understanding is one metric that has been historically valued in PER and in the assessment of physics-education-research-based instructional materials. Attending to COnceptual Resources iN (ACORN) Physics Tutorials are instructional materials that are based on research that identifies common conceptual resources—good ideas or "seeds of science" which can be developed into more sophisticated scientific understanding. For this study, we used pre- and post-tests and classroom video to assess students' conceptual understanding as they completed an ACORN Physics Tutorial about electric circuits. We present the results of our analysis in this talk. This work has been supported in part by NSF grants 1914572 & 1914603.

I06-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Two Perspectives on Physics Problem Solving and Their Relations to Adaptive Expertise

Presenting Author: Eric Kuo, University of Illinois Urbana-Champaign

This talk reviews two historical threads of research in physics problem solving. Thread 1 focuses on classifying and teaching students to (re)produce expert solution methods. Work within thread 1 has focused on expert knowledge and strategies, training students to learn expert-like problem-solving methods, and algebraic and computational difficulties. Thread 2 focuses on the role of problem solving in the practice of learning and understanding physics. In contrast to an emphasis on producing solutions, thread 2 focuses on the formal and informal ideas used in physics problem solving and how problem solving connects to other aspects of physics learning. After summarizing major research areas within these two threads, both will be discussed in terms of how they relate to adaptive expertise and interpret the key question of transfer. Finally, open questions for future problem-solving research will be raised. An elaborated version of this review is available as a chapter in the International Handbook of Physics Education Research: Learning Physics.

I06-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | Using Reasoning Chain Construction Tasks to Guide Student Discussion about Reasoning in Physics

Presenting Author: Michael Pedicone, University of North Florida

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

Reasoning on qualitative physics problems is usually expected to be deductive in nature – one might start with first principles and then add contextual information about the problem to derive conclusions specific to the given scenario. Students often find this process difficult. Reasoning chain construction tasks, or chaining tasks, have been used to study student reasoning skills and examine different theoretical models of reasoning. In a chaining tasks, a student is given a series of reasoning elements and asked to assemble the elements into a chain of reasoning that leads to a specific conclusion on a physics task, thus highlighting the underlying deductive process. In the context of an algebra-based physics 2 course, we used an online chaining task followed with an in-class discussion of the results to promote a deeper understanding of how reasoning chains are used in physics. Key insights related to student's understanding of the reasoning process will be discussed.

I06-04 (9:36 to 9:48 AM Wednesday) | Contributed Talk | Examining Procedural Resources Via Online Reasoning Chain Construction Tasks

Presenting Author: J. Caleb Speirs, University of North Florida

Additional Author | Alexa Koenig, University of New England

Additional Author | Nathan Brown, University of New England

Online reasoning chain construction tasks have been used to study patterns in student qualitative reasoning and to test predications based in dual-process theories of reasoning. Here, we use the resources framework to develop a reasoning chain construction task aimed at probing the development of algebraic procedural resources. Previous studies have suggested that as mathematical fluency increases, students move from step-by-step procedures ("cancel", "divide", "subtract") to more reified cognitive constructs that incorporates each step into a single resource (such as "separate variables"). Furthermore, it is suggested that as mathematical fluency increases, operations become more gestural and visual in nature ("move this to that side") rather than strictly operational ("subtract x from both sides"). We therefore created a chaining task which includes both types of elements, some including gestural language, and some including operational language, and distributed the task to populations of differing mathematical backgrounds and confidence levels. Results of this study will be shared.

Session I07: Developing and Evaluating Upper-Level Experiences: Labs and Capstone

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Kara Beauchamp

I07-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Teamwork Experiences in a Year-long Industry Senior Capstone Course

Presenting Author: Victoria Borish, University of Colorado Boulder, JILA

Additional Author | Kristin Oliver, University of Colorado Boulder, JILA

Additional Author | Bethany Wilcox, University of Colorado Boulder

Additional Author | Heather Lewandowski, University of Colorado Boulder, JILA

Teamwork is an important practice for physicists both in academia and industry, and thus was a key part of a new year-long physics capstone course focused on collaboration with the quantum industry. In this course, five to eight students worked together on a year-long authentic project with an industry partner. We present some preliminary findings about these students' experiences with teamwork in this new context, including their satisfaction with the assigned group roles and the way the project brought the students together and helped them build friendships.

I07-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Making Nuclear Magnetic Resonance More Accessible

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) has played an important role in science since the mid-20th century - garnering five Nobel prizes across physics, chemistry, and medicine. NMR remains a crucial analytical and diagnostic tool in these scientific disciplines and can also provide our students with a valuable introduction to modern-day quantum technology and research. Currently, students learn about NMR (if ever) in advanced undergraduate research labs and courses. This talk introduces a set of lab-based activities developed as part of an NSF-IUSE grant to help make NMR more accessible to students and integrate NMR into the undergraduate science curriculum. These modular labs were designed to cover the theory and applications of NMR in a truly multidisciplinary way as well as have the 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 work we have done so far in this project and our goals for the future.

I07-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | Assessing the Impact of Nuclear Magnetic Resonance Labs

Presenting Author: Dedra Demaree, Blue Ridge School

Additional Author | Merideth Frey, Sarah Lawrence College

Additional Author | Colin Abernethy, Sarah Lawrence College

Additional Author | David Gosser, City College of New York

An extensive set of lab-based activities are being developed as part of an NSF-IUSE grant to help make NMR more accessible to students and integrate NMR into the undergraduate science curriculum. To date, many of the activities have been used in the classroom - both in chemistry and physics contexts. We have collected and are in the process of analyzing data to assess their efficacy. These labs are strongly influenced by the Investigative Science Learning Environment (ISLE) philosophy, including observation and testing experiments. Therefore, we are collecting 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 new lab-based activities.

I07-04 (9:36 to 9:48 AM Wednesday) | Contributed Talk | Gee-Whiz: An Update on our Design of Undergraduate Experiments on Ultrafast Lasers

Presenting Author: Lalitasri Nandivada, University of Waterloo

Additional Author | Meg Ward, University of Waterloo

Additional Author | Karen Cummings, University of Waterloo

Additional Author | Donna Strickland, University of Waterloo

In this presentation, we will discuss the continuation of our construction of our Gee-Whiz experiments. These experiments focus specifically on techniques in ultrafast laser physics. We have been developing an experiment in frequency doubling and autocorrelation, both of which make use of an ultrafast laser. The experiment is especially noteworthy at Waterloo because it is part of a new "Gee-Whiz" set of experiments we are developing to help stimulate positive results in line with the expectations laid out by Self Determination Theory. This experiment embodies modeling-based designs similar to those developed by Dr. Natasha Holmes and Dr. Carl Wieman at the University of British Columbia and Cornell University. We are currently surveying our junior and senior physics lab students to understand the impact lab education has on their perspective towards experimental physics and perceived agency and also report on these findings. These attitudinal findings are further discussed elsewhere.

Session I08: Teamwork in Labs: Guidance for Instruction

Location: Ballroom A09 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Danny Doucette

I08-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Teaming for Success: Developing Student Skills in Engineering Physics Labs

Presenting Author: Darsa Donelan, Gustavus Adolphus College

In the professional world, strong teaming skills are essential for success. This is why cultivating critical teaming skills is also an essential aspect of the physics laboratory experience, where students can learn how to better function on a team and benefit from team experiences in the future. In this talk, I will describe how a first-year, first-semester course on engineering physics provided students with a project-intensive laboratory experience with an emphasis on team building and project management skills themed around sustainability and climate change. Students gained an understanding of their personalities, learned how to develop empathy with others, and honed skills for conflict resolution and prevention. By incorporating real customers into their projects, students were able to feel the authenticity of their work and develop their engineering identities. We will also discuss our main takeaways and how other instructors can benefit from our experience in teaching teaming skills to their own students.

I08-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Our Experience Redesigning a First-year Laboratory Course and Introducing a New Team Structure

Presenting Author: Sarah Johnson, Simon Fraser University

Additional Author | Daria Ahrensmeier, Simon Fraser University

In the mid-2010's, a team in the Department of Physics at Simon Fraser University redesigned our two first-year laboratory courses. Our goal was primarily to provide a better introduction to the concept of experimental uncertainty in measurement. Experiments were chosen to emphasize concepts students have particular difficulty with, where learning can benefit from measurement. We consulted the "AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum" report (2014) as well as PER literature on labs during our development process. As well as updating the curriculum, we decided to change the structure of the student teams and how they function. The new team structure involved students working in groups of three with assigned roles that rotate weekly. In this talk, we will share instructor experiences in the redesigned courses over the last 8 years or so with an emphasis on the impact of the team structure to student learning and engagement.

I08-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | Prelab Reflections for Trying on Group Roles

Presenting Author: Bradley McCoy, Azusa Pacific University

Effective collaboration requires fulfilling of several roles within a team. We use the framework of Holmes et al. for group roles of principal investigator, science communicator, data analyst, theorist, and skeptic and propose technician as an additional role. In this talk, I will describe initial implementation of a prelab assignment in which students reflect on the role they play in a group, designed to prompt metacognition and encourage trying out new roles.

Session I09: Some Interesting Bauder Fund Projects

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Thomas O'Kuma

I09-01 (9:00 to 9:24 AM Wednesday) | | Quantum Party! An Educational Board Game...with Quantum Mechanics!

Presenting Author: Matthew Bellis, Siena College

Additional Author | Germaine Gatewood, Siena College

Students have a tremendous amount of competition for their attention (social media, extracurricular activities, jobs, etc) making it a challenge to occupy their head space. Starting in 2018 and greatly aided by a Bauder Fund grant, a small group at Siena decided to address this challenge by developing a board game that teaches quantum mechanics at the middle- and high-school level, driven by rules inspired by the science behind 4 classic science experiments/observations: the double slit experiment, blackbody radiation, the photoelectric effect, and the Rutherford scattering experiment. The game was completed in 2021 and is currently available for purchase from an independent games-manufacturer, The GameCrafter. In addition to the game board and pieces, the game comes with a pamphlet that concisely describes the science behind the game at an introductory level. In this talk, I will share our experience designing the game and feedback from teachers and students about how it might be used in the classroom.

I09-02 (9:24 to 9:48 AM Wednesday) | | "Shedding Some Light" Spectroscopy Investigation

Presenting Author: Angela Douglass, Ouachita Baptist University

Additional Author | Susan Allison, Dawson Education Cooperative

Spectroscopy allows us to discover the chemical makeup of stars, planets, and distance galaxies. It also helps us study the structure of atoms and molecules here on earth. It is a beautiful, powerful tool that is used in astronomy, chemistry, physics, and biology, as well as the medical field and forensic science. In this presentation, we will share an inquiry-based lesson we developed on light and spectroscopy using the new, spectrum-looking Netflix logo as our hook for middle and high school students. In this lesson, students observed the unique spectra of several gases and were guided to discover the mathematical relationship between the frequency and wavelength of light. In addition, students practiced math skills such as ratios and graphing and learned about the history and applications of spectroscopy. A Bauder Fund awarded in 2021 made it possible to purchase gas emission tubes, power supplies, and diffraction glasses needed to take this lesson to local students.

Session I10: Uncommon Uses for Common Things

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Paul Noel

I10-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Manipulating Paper to do Physics: Square Twist Race Activity

Presenting Author: AdeBanjo Oriade, University of Delaware

Teaching and Learning outcomes of designing and running an origami paper twist race activity are shared in this talk. In the activity students first document predictions and a hypothesis. Next, they make preliminary measurements before cutting the templates and folding three different square twists (A, B, and C) from the same size paper. One of the predictions is the outcome of the race, when partially open square paper twists are dropped from the same height. This activity was run at informal events with middle, and junior high school students. It was also run as part of a college level course, Origami Science. The exercise concludes with analysis of a video of the race. The sound level peaks at this concluding part where there is active intra and inter group discussion. All participants show evidence of learning science by doing science. More than one NGSS science practice was demonstrated. Making predictions (response to the question, "What will happen?") is easier than composing a hypothesis (response to the question, "Why will what you predict will happen, happen ?"). What is your take on the use of this and similar paper design activities to increase student engagement in science learning spaces?

I10-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Game Show Final: Creative Physics with Common Items

Presenting Author: Donald Smith, Guilford College

Final exam season. Students cram late into the night, memorizing equations that will be forgotten before the week is out. Professors must assign grades to stacks of paper, wondering if students will ever even look at the feedback. I have found a solution that cuts through the suffering and provides a memorable, and even fun, experience for the whole class: turn the final into a game show. Inspired by the international cooking show, Iron Chef, I have been ending my introductory classes with Iron Physicist! Students are told in advance they will have two hours to design and carry out a Physics experiment, with the single constraint that it must use in some way a secret ingredient that they will only discover on the day. I have used pickles, bananas, marshmallows, lemons, paper clips, and rubber bouncy balls. I will describe how the students responded to this experience, and what some of their challenges were. Instead of a stressful ordeal, we end the semester with a celebration of what they have accomplished, and students report even years later that it was a highlight of their experience.

I10-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | Physics at Home: Demonstrations with Things that Students May Already Have

Presenting Author: W. Blake Laing, Southern Adventist University

A ukulele can be used to demonstrate some properties in common with a confined quantum system: quantized frequencies and (classical) superposition. A hardware store "laser line level" can be used for ray tracing on the whiteboard. A medicine ball can be used to demonstrate that a particle moving in a straight line does have angular momentum. A bathroom scale can be used for static equilibrium demonstrations. Action figures and a camera can be used to anchor discussions of relativity.

Session I11: Science Communication

Location: Meeting Room 02 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Jonathan Perry

I11-01 (9:00 to 9:12 AM Wednesday) | Contributed Talk | Integration of Multimedia Technology for Physics Outreach and Public Engagement

Presenting Author: Angella Johnson, angella_johnson@brown.edu

Current media platforms can be utilized for physics outreach and public engagement. Analysis shows that successful retention of students in science disciplines occurs at middle school age. If engaged at this critical stage, students are more likely to pursue advanced degrees in science. Our video series, Physics Fundamentals, is particularly geared to this target audience but also includes science enthusiasts. Each episode covers a physical phenomena in an entertaining and educational way which encourages self-learning and exploration. Preliminary results show that the videos have made an impact in the online community. Additionally, these videos can be used as a resource for teaching physics in the classroom
Physics Fundamentals Videos https://bit.ly/442tTFl
Brown University YouTube Channel https://www.youtube.com/@brownuniversitydepartmento5643

I11-02 (9:12 to 9:24 AM Wednesday) | Contributed Talk | Expanding the Scope of Science Communication: Using Youtube for Systemic Change in Physics

Presenting Author: Fatima Abdurrahman, University of Maryland, College Park - Department of Physics

While social media is widely understood as a powerful tool for science communication, its potential may be limited by the emphasis on online content that teaches domain knowledge. Beyond the explanation of physics concepts, platforms like Youtube can facilitate the sharing of resources and pedagogical knowledge between educators, as well as the rapid communication of findings between education researchers. Over the past year, I have been experimenting with Youtube science communication by making videos examining systemic issues in physics/astronomy higher education. In less than ten months, my channel ("Dr. Fatima") has amassed over 200,000 views and an audience of over 16,000 subscribers. Through this work, I have identified a multitude of audiences eager to watch and engage with this type of content, including prospective and current STEM students, high school and college level STEM educators, and non-STEM associated viewers who have a general interest in the field. In this talk, I will use viewer analytics, video comments, and my general experiences to argue that expanding our understanding of what falls under the umbrella of "science communication" and who we aim to reach with it can better serve the needs of the physics community in a holistic sense. I am also submitting a proposal for a companion interactive session with the same title---the two talks are not redundant, but discuss/explore different aspects of the work.

I11-03 (9:24 to 9:36 AM Wednesday) | Contributed Talk | A Very Successful Planetarium Show for Students and the Public

Presenting Author: Michael Barnett, Lawrence Berkeley National Lab

Three physicists made a highly successful planetarium show about Dark Matter called: Phantom of the Universe. It has been seen worldwide by over two million people. It has been in more than 730 planetariums in 74 countries and in 27 languages. Our target audiences were students and the public. For most planetariums, school visits account for about half their audiences. We found that many planetariums had a great interest in a dark matter show. They present our show for months at a time (unlike feature films). Planetariums have the perfect science-interested audience for us in students and the general public. Narration was by Academy Award-winning actor Tilda Swinton. Sound was done with an Academy Award-winning team at Skywalker Sound.

I11-04 (9:36 to 9:48 AM Wednesday) | Contributed Talk | The Tentativeness and Trustworthiness of Science

Presenting Author: Jocelyn Robbins, University of Colorado Boulder

Additiional Author | Bethany Wilcox, University of Colorado Boulder

This study explores how educational experiences influence students' understanding of the tentativeness and trustworthiness of science. Previous researchers created instruments to measure how an individual's educational experience impacts their understanding of the tentativeness of science and identified factors that affect trust in science. However, no studies looked into education, trust, and the tentativeness of science together. To address this relationship, we created a survey with open-ended questions and likert-style items. After distributing the survey, we used statistical hypothesis testing to determine if any correlations existed between questions and different demographics groups. Contrary to what we expected, the results found that formal collegiate education was not a significant predictor of ideas about the tentativeness and trustworthiness of science; rather, political party affiliation was the strongest predictor of an individual's responses. Further research in this area could explore the relationships of intersectional identities and the impact of different types of education.

Session I12: Round Table: Graduate Education in Physics

Location: Meeting Room 03 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Douglas Petkie

I12-01 (9:00 to 10:00 AM Wednesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Graduate Education in Physics Round Table Discussion

Presenting Author: Douglas Petkie, Worcester Polytechnic Institute

In this interactive round table discussion hosted by the Committee on Graduate Education in Physics, various stakeholders will discuss topics relevant to graduate education in physics, including undergraduate preparation for graduate school, the change admissions landscape, graduate school access, diversity and equity in graduate school, and preparation of graduate students for careers post-graduation.

Session I13: Workshop 1: Technology for Labs

Location: Meeting Room 04 **Sponsor:** AAPT **Time:** 9–10 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Tom Herring

I13-01 (9:00 to 9:24 AM Wednesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Investigating Magnetic Fields using the 3-Axis Magnetometer on your Smartphone

Presenting Author: David Rakestraw, Lawrence Livermore National Laboratory

In this interactive session, participants will conduct investigations of magnetic fields and their application using the 3-axis magnetometer which is available on every smartphone and accessible to almost every student. Every participant will actively investigate: 1) Earth's magnetic field and characterize its magnitude and inclination angle, 2) magnetic field lines surrounding a dipole magnet with extraordinary precision, 3) magnetic field produced by a current carrying wire, and 4) demonstrate the principles of magnetic storage by encoding a byte of information using 8 ferromagnetic nails and reading out the information using the magnetometer. Each of these "experiments" enable an in-depth laboratory activity which educators can implement in their classrooms or assign students to do at home. The activities use minimal additional supplies beyond the smartphone which most students already own. During the session, every participant will be provided a few simple supplies so they can carry out the investigations. These simple activities on magnetism represent just a small sampling of the extraordinary hands-on opportunities for students to investigate the world around them using the remarkable capabilities of smartphone technology. Participants will be directed to more detailed resources on a wide range of physics topics, which are all freely available. I have written the abstract for an activity where all the participants will conduct the series of activities described. The activities are very engaging and people are usually delighted as they see what is possible using the magnetometer on their phones. I will bring supplies to allow all participants to conduct the activities. I will also bring about 10 extra phones that people can use if they do not have their own phones. These activities will need to have tables for participants to carry out the investigations.

Session J01: Effective Practices in K-12 II

Location: Ballroom A02 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Duane Merrell

J01-01 (10:00 to 10:12 AM) | Contributed Talk (12 Minutes) | Empowering Students as Scientists: Redesigning PhysicsQuest to Foster Inclusion and Engagement in Middle School Classrooms

Presenting Author: Sierra Crandell, University of Colorado Denver with American Physical Society

PhysicsQuest is a program that provides educators and students with high quality, hands-on physics experiments and has been at APS since 2003. Many of you may be familiar with the PhysicsQuest Spectra comics, but evaluation reports based on teacher feedback state that although the comics add to the overall experience, few students read them and they had little connection to science content. We want students to be engaged and empowered to feel like scientists over superheros. Therefore the APS PhysicsQuest team has embarked on updating the previous PhysicsQuest activities to be more aligned with NGSS practices, DEI strategies (including the STEP UP Everyday Actions guide), and research - based discussion methods. In this talk we will review the process used to update the activities as well as show middle school teachers how to access these free, readily available lab activities for use in their classrooms. If we can help students cultivate a positive experience in middle school, we hope that they will continue to explore the world and feel confident in their ability as current and future scientists.

J01-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk | Waves and Sound: A 5th Grade Summer Camp

Presenting Author: Bryn Bishop, Art of Problem Solving

At the Art of Problem Solving, our mission is to train the great problem solvers of the next generation, and to do this, we've been building our suite of science courses. In this talk, I'll share our design process for creating these courses and introduce our newest course - an interactive and rigorous summer camp for fifth and sixth grade students. This two week course focuses on mechanical waves with an emphasis on sound waves and includes labs and problems using various musical instruments, sound spectrum, and SONAR. I will share our insights and challenges for writing curricula accessible to younger audiences.

J01-03 (10:24 to 10:36 AM Wednesday) | Contributed Talk | Creating a Comic Book to Help Students Learn Problem-Solving

Presenting Author: Juan Ramírez de Arellano, Tecnológico de Monterrey, Campus Ciudad de México

Co-presenting Author | Roger A. Freedman, University of California, Santa Barbara

The comic book or graphic novel has been used as an educational tool at many levels, from young readers to business school students. We are creating a series of comic book stories intended to help high school and introductory college students with solving specific types of physics problems that most students find challenging. In this talk we'll describe how our backgrounds led us to this approach (JMRdeA is a theoretical condensed-matter physicist as well as a professional cartoonist, RAF is a physics textbook author and one of the original group that helped start the San Diego Comic-Con in the 1970s) and recount some of the history of teaching science through comics. We'll show examples of our work so far (which is available in both English and Spanish) and describe the enthusiastic response we've received from high school and college students who've used our comics.

Session J02: Innovations in Teaching Astronomy

Location: Ballroom A03 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Kevin Lee

J02-01 (10:00 to 10:12 AM Wednesday) | Contributed Talk | Astronomy Majors Challenging the Lone Dead White Man Narrative: Cultural Cosmology Projects

Presenting Author: Kim Coble, San Francisco State University

Additional Author | Kim Long Le, San Francisco State University

Additional Author | Janelle M Bailey, Temple University

Exploring cultural aspects of cosmology (such as those of Indigenous, non-Western, or marginalized groups) can support an inclusive environment within astronomy. At a large, ethnically diverse, master's-granting institution in California, astronomy majors are required to take a writing-intensive

course that integrates cosmological science, research techniques, and the cosmological worldviews of human cultures over space and time. We describe the cultural cosmology project, which includes instructions to investigate cosmologies of indigenous or other marginalized groups or to challenge modern science's dominant cultural narratives. Using an iterative thematic coding approach, we analyze course artifacts and interviews to identify the "what, why, and how" of approaches students took in their projects. Students frequently studied a culture that was related to their heritage and identity, and many identified ways in which the cosmological beliefs of their selected culture(s) overlapped or aligned with current science, within the culture's technological abilities. Students highlighted the need to change perceptions and bring accomplishments to light. Many pointed out the destructive process of colonialism, but that they are the living survivors, carrying on cultural traditions and doing science. Many also felt that indigenous cultures provide models for humanizing science and integrating their whole selves with their scientist identities.

J02-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk | Creating Powerful Educational Experiences in a General Education Astronomy Course

Presenting Author: Garett Yoder, Eastern Kentucky University

Additional Author | Mark Pitts, Eastern Kentucky University

Additional Author | Jessica Lair, Eastern Kentucky University

Additional Author | Jing Wang, Eastern Kentucky University

Utilizing the resources from the EngaGE program at Eastern Kentucky University, the Department of Physics, Geosciences, & Astronomy has reimagined their general education astronomy course. We Have moved from the standard 2 hours of lecture and 2 hours of a separate laboratory section to an integrated lecture-laboratory format. We are utilizing the Hummel Planetarium, a long-time feature of the EKU campus, as the instructional space for the course and have a telescope deck to facilitate outdoor observing sessions. We are committed to active classroom experiences and have generated sets of activities, including laboratory exercises, as the backbone structure of the course. We will discuss the structure of the new course and the benefits we have seen as a result of this course renovation.

J02-03 (10:24 to 10:36 AM) | Contributed Talk | Improving Competency, Motivation, & Engagement in Teachers & Students with Astronomy Modeling Instruction with Exoplanets

Presenting Author: Daniel Peluso, University of Southern Queensland & SETI Institute

Additional Author | Colleen Megowan-Romanowicz, American Modeling Teachers Association (AMTA)

Additional Author | Carl Pennypacker, UC Berkeley & Lawrence Berkeley National Laboratory

Additional Author | Franck Marchis, SETI Institute & Unistellar

Additional Author | Bradley Carter, University of Southern Queensland

Additional Author | Duncan Wright, University of Southern Queensland

We present results from a mixed methods study exploring outcomes from an inquiry-based data-driven Modeling Instruction astronomy course called, Astronomy Modeling with Exoplanets (AME). The study included teachers and students. Teachers mostly represented US high school physics teachers with little to no background in astronomy or astrophysics and who were planning to or interested in teaching a high school astronomy course. A subset of teachers were administered pre- and post-course surveys and participated in semi-structured interviews to explore changes in pedagogy, confidence, motivation, and astronomy competency. Students involved were US high school astronomy students who took AME from a teacher who completed the teacher version of AME. Students received a similar mixed methods procedure, except focused more on student engagement and thoughts on the course. Quantitative results show statistically significant improvement in both teacher and student astronomy competency and qualitative results show changes in teacher pedagogy that was more engaging for students. Students who took AME reported to enjoy working with real exoplanet data versus learning from a book. Teachers who completed AME were capable of implementing astrophysics activities in a high school setting, which is likely more rigorous than introductory level descriptive astronomy courses at the collegiate level.

Session J03: Effective Practices for Developing Scientific Thinking, Reasoning, and Decision-Making Abilities – Investigating Science Practices

Location: Ballroom A04 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Paul Emigh

J03-01 (10:00 to 10:12 AM Wednesday) | Contributed Talk | Identifying Science Practices in an Upper-Division E&M Activity

Presenting Author: Jonathan Alfson, Oregon State University

Additional Author | Paul J Emigh, Oregon State University

Additional Author | Elizabeth Gire, Oregon State University

We discuss how the science practices of Developing and Using Models, Using Mathematics and Computational Thinking, Constructing Explanations, and Engaging in Argument from Evidence are supported in an upper-division electrostatics activity featuring multiple external representations. In this small-group activity, students considered the electric potential of two configurations of point charges. The students had access to a tabletop whiteboard, a pre-programmed Mathematica notebook, and a dry-erasable 3D plastic graph. For this analysis, we examine a subset of the science practices defined within the Next Generation Science Standards (NGSS) and how using these multiple external representations influenced the science practices of a group of three students. We find that the whiteboard is well-suited for developing models and using mathematics, while the Mathematica notebook and plastic graph both facilitated constructing explanations and engaging in argument from evidence.

J03-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk | Elevating LCA (limiting case analysis) as a Classroom Activity

Presenting Author: Gary White, George Washington University and AAPT

Additional Author | Tiffany-Rose Sikorski, George Washington University

Limiting case analysis (LCA) is commonly used by practicing physicists, and is often cited as an important part of thinking like a physicist…but, there is little in the literature about how students learn LCA and little about what students learn from LCA. We present here briefly LCA as it appears in three venues: historical/philosophical writings, textbooks, and research investigations into student use of LCA. Next, we describe the results of our study of four successive classes of an upper-level

electrodynamics course wherein the instructor (GW) emphasized routine use of LCA, exploring students' written responses to prompts intended to foster LCA. In addition to presenting new results about how students articulate and compare their use of LCA to their intuition, we also provide new framing for the instructional goals of LCA in theoretical terms via the concept of adaptive expertise. Finally, we close with a discussion that provides our take on the research and teaching implications of the study.

J03-03 (10:24 to 10:36 AM Wednesday) | Contributed Talk | Introductory Mechanics in Parallel

Presenting Author: Jennifer Klay, Cal Poly San Luis Obispo

Additional Author | Pete Schwartz, Cal Poly San Luis Obispo

Parallel Pedagogy is a novel introductory physics curriculum developed by Pete Schwartz at Cal Poly San Luis Obispo. Students explore the four lenses of mechanics (momentum, energy, dynamics, kinematics) in parallel and learn how to apply them to investigate, explain, and solve problems they've never seen before. Instead of learning concepts in isolation from each other, we introduce all four concepts together in the first unit. Starting out simply with one-dimensional motion, we build in complexity week by week. The goal of the curriculum is to help students develop proficiency in thinking about problems like an expert, considering multiple angles before attempting a solution and supporting their results with conceptual reasoning. Freely available course materials are provided through Canvas Commons, including comprehensive video lectures, textbook modules, problem sets, and more. A recent article evaluating the effectiveness of the curriculum in improving concept application by students will be reviewed Through this talk we hope to build collaboration with others interested in making the leap to Parallel Pedagogy. *The Physics Teacher* **60**, 508 (2022); https://doi.org/10.1119/5.0053341 *The Physics Teacher* **55**, 280 (2017); https://doi.org/10.1119/1.4981034

J03-04 (10:36 to 10:48 AM Wednesday) | Contributed Talk | Parallel Pedagogy, and an OER textbook to go with it

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

Parallel Pedagogy, which is similar to Spiral Physics, has been shown to promote expert-like thinking and better attitudes toward physics. This pedagogy introduces the four main concepts of mechanics: motion, forces, momentum, and energy in the first week and develops these ideas in parallel, starting with very simple physical scenarios and gradually increasing the complexity of the scenarios over the course of the semester. This format encourages students to constantly consider the relevant concepts for solving a problem in physics, instead of assuming, for example, that all problems should be solved using the concept of momentum for the "momentum" chapter of the textbook. The free OER textbook is laid out in a three-column format: Words, Graphics, and Numbers, emphasizing the importance of each of these "languages" in understanding and explaining physics.

Session J04: PER & DEI II

Location: Ballroom A05 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Brianne Gutmann

J04-01 (10:00 to 10:12 AM) | Contributed Talk (12 Minutes) | Development of Physics Affinity in Introductory Physics for Life Science Students Across Three Institutions

Presenting Author: Angelina Tjia, Swarthmore College

Additional Author | Drake Roth, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Lili Cui, University of Maryland, Baltimore County

Additional Author | Alfredo Sanchez, Swarthmore College

Additional Author | Benjamin D Geller, Swarthmore College

Previous work has found that at one institution, life science students' evaluation of the value and relevance of studying physics increases after taking a year-long introductory physics course that has been reformed to highlight connections between physics and the life sciences; furthermore, such gains persist for at least a year or more after Instruction. As a first step toward determining the generalizability of this previous work, we report on the development of what we call "physics affinity" — student self-efficacy, interest, achievement goals, and views about the relevance of physics — among introductory physics for life science students at three different institutions. To begin to interpret our findings, we compare the three course environments and the three approaches to incorporating life science connections. We also report preliminary results from triangulation of survey results with student written reflections and case study interviews from the institution where the original results were obtained.

J04-02 (10:12 to 10:24 AM) | Contributed Talk (12 Minutes) | Methodologies in Assessing Student Engagement in Introductory Physics for Life Sciences

Presenting Author: Stephen Hackler, Swarthmore College

Additional Author | Catherine H Crouch, Swarthmore College

Additional Author | Benjamin D Geller, Swarthmore College

Previous work studying the sources of student engagement in introductory physics for life science courses have revealed that such engagement is the product of numerous factors, including instructor messaging, course policies, and assessment design. This work made use of both quantitative (completion of assessments, questionnaire responses, etc.) and qualitative data (student interviews, journal prompts, open-ended questionnaires, etc.). In the next stages of our work, we hope to understand a more detailed mechanism by which our course achieves its outcomes. To do this, we examine the specific methodologies that we currently use to explore students' engagement pathways and refine said methodologies to better understand how the course elements produce the observed engagement pathways. Such findings will shed light on the potential generalizability of current methods and findings, providing a foundation for other institutions looking to support similar engagement pathways for their students. We present an overview of the techniques we have used to gather data for this work and our plans for revising and updating these methodologies for future work in introductory physics for life science courses.

J04-03 (10:24 to 10:36 AM) | Contributed Talk (12 Minutes) | Developing Neurodivergent Students' Critical Disability Physics Identity

Presenting Author: Liam McDermott, Rutgers University

Additional Author | Nazeer A Mosley, Rutgers University

Neurodivergent students experience the physical world in a non-normative way due to differences in sensory-cognitive processes like concept mapping and mathematical and physical sense-making. The often rigid structure of educational institutions regularly runs counter to neurodivergent students' natural ways of learning physics concepts and performing physics tasks, which commonly results in outright and structural discrimination against these students. Neurodivergent non-normative sense-making and concept mapping also creates countersocialities or ocunterconceptualization of the physical world which lead to unique, valuable perspectives and methodologies in science. It is important therefore, that we, as educators, encourage identity development which counteracts the negative and ableist structures of our institutions and assure that our neurodivergent students see themselves as valuable and contributing members of our laboratory and classroom community. In this talk, I present on research pertaining to the operationalization of our Critical Disability Physics Identity, and report on conclusions drawn regarding the identity development of our neurodivergent students.

J04-04 (10:36 to 10:48 AM) | Contributed Talk (12 Minutes) | Learning in Interaction: Interacting Scales of Research

Presenting Author: Gina Quan, San José State University

Additional Author | Enrique Suárez, University of Massachusetts Amherst

Additional Author | David Hammer, Tufts University

Additional Author | Leslie Atkins, Boise State University

This talk presents a literature review of different scales of research in PER which have considered dynamic, ecological accounts of learning. We consider research that has focused on three broad (and fuzzy) scales of interactions: (1) interactions between cognitive elements in the mind, (2) interactions among groups of people in a learning setting, and (3) interactions with institutions, cultures, and societies. At these three scales, these models encapsulate our field's attempt to represent and simplify a dynamic, complex system. We consider how each scale offers layered insight into the processes of learning and suggests different instructional approaches. We argue for the productivity of attending to interactions between all three scales and how they shape teaching, learning, and becoming in physics classrooms.

J04-05 (10:48 to 11:00 AM) | Contributed Talk (12 Minutes) | Inclusiveness of learning environment predicts student physics motivational beliefs and Force Concept Inventory scores

Presenting Author: Chandralekha Singh, University of Pittsburgh

Additional Author | Yangqiuting Li, University of Pittsburgh

Student motivational beliefs such as self-efficacy, interest and identity in physics can influence their learning, performance and career decisions. Therefore, we conducted a study on students' motivational beliefs and Force Conceptual Inventory (FCI) scores in a college calculus-based introductory physics sequence to investigate how students' perception of the inclusiveness of learning environment predicts students' self-efficacy, interest, identity and FCI scores. Findings can be useful in creating equitable and inclusive learning environments in which all students can thrive. We thank the National Science Foundation for support.

Session J05: PER & Assessment Ideas V

Location: Ballroom A06 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Gina Passante

J05-01 (10:00 to 10:12 AM Wednesday) | Contributed Talk | Comparison of Rater Labeling Versus Multiple-Choice Responses for Natural Language Processing to Predict Student Problem Solving Performance

Presenting Author: Winter Allen, Purdue University

Additional Author | Jeremy Munsell

Additional Author | Carina M Rebello, Toronto Metropolitan University

Additional Author | N. Sanjay Rebello, Purdue University

In an online quiz taken by students in a large-enrollment calculus-based course at a large Midwestern University, students were tasked with solving a "ballistic pendulum" physics problem. After solving the problem, they were asked to describe the general problem-solving strategy they used in a written essay. We used machine learning to predict whether students will correctly solve the problem. Student essays were codified using methods of natural language processing. Essays from two non-consecutive semesters were used for training/validation (N = 1480) and testing (N=1441). For the training/validation, student essays were labeled using two methods. First, they were labeled using the correctness of student answers to the multiple-choice question. The other method we used to label the student essays was with human raters with sufficient interrater reliability. The accuracy in predicting students' correctness was tested and compared between the two methods of labeling the training set. We report on the results of the accuracy of the predictions of the machine learning algorithm.
Supported in part by U.S National Science Foundation Grant 2111138.

J05-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk | Predicting At-Risk Students in an Introductory Physics Course with Machine Learning

Presenting Author: John Pace, West Virginia University

Additional Author | John C Stewart, West Virginia University

Additional Author | John Hansen, West Virginia University

The use of machine learning algorithms to predict student performance in an introductory mechanics class represents a promising avenue to identify students likely to struggle and to direct additional resources where they are most needed. Machine learning is applied to a dataset consisting of institutional variables (college GPA, ACT/SAT scores), course performance variables (homework averages and clicker scores), and non-cognitive variables (self-efficacy and belonging) gathered from the first two weeks of class to predict students at risk of failing the course. The results of using a logistic regression classifier with various modifications to account for imbalanced data, including decision threshold tuning and synthetic upsampling, are presented. Additionally, techniques to measure the effect of certain variables on model performance and to select an optimally performing set of input variables are explored. The best-performing models achieved a balanced accuracy of around 82%.

J05-03 (10:26 to 10:36 AM Wednesday) | Contributed Talk | Experiences with Students "Self-grading" Their Homework in Introductory and Qdvanced Courses

Presenting Author: John Milsom, University of Arizona

While faculty often write detailed solutions to homework sets, the vast majority of students never look at them or if they do they examine them the morning of the exam. Unfortunately, they aren't trying to learn from their mistakes. For several semesters, I have been having students "self-grade" their own homework. They are required to compare their answer to my key and comment on any mistakes they have made. Additionally, they are expected to write a few sentences summarizing their overall performance on the entire assignment. In this talk, I will discuss my experiences with this in both introductory and advanced courses.

J05-04 (10:36 to 10:48 AM Wednesday) | Contributed Talk | Student Perceptions of Grading Practices

Presenting Author: W. Brian Lane, University of North Florida

Co-presenting Author | J. Caleb Speirs, University of North Florida

Additional Author | Sarah Nguyen, University of North Florida

Additional Author | Mark Swartz, University of North Florida

Additional Author | Michael Pedicone, University of North Florida

Additional Author | Naomi Laird, University of North Florida

Prior research has indicated that an instructor's choice of grading practices can influence learning outcomes. For example, students in a physics class describe adopting different epistemologies based on whether a course is taken for a letter grade versus just to learn physics well. Additionally, the choice between a percent grading scale and a 4-point grading scale significantly alters the equity of a course's grade distribution. For these and other related reasons, alternatives to traditional grading, such as standards-based grading, contract-based grading, and student self-evaluation, are gaining popularity. Effectively implementing such alternatives requires illuminating the mechanisms by which grading practices mediate student learning to ensure the alternatives do not recreate these problems or introduce new problems. As a first step in this process, we conducted a series of focus groups with introductory physics students at a mid-sized regional state university to understand how they perceive the traditional grading process and potential alternatives. We explore how students interpret grades, how they evaluate fairness in grading, and how they believe grades should balance understanding of content with effort exerted.

Session J06: PER into Student Understanding (including assessment instruments)

Location: Ballroom A07 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Karen Cummings

J06-01 (10:00 to 10:12 AM Wednesday) | Contributed Talk | Exploring the Expertise Reversal Effect in the Context of Multimedia Instruction

Presenting Author: Razan Hamed, Purdue University

Co-presenting Author | Jeremy Munsell, Purdue University

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

We designed an online instructional module to teach the concepts of force and motion. The module was created in two versions, taking into account the expertise reversal effect, which suggests that different levels of guidance may be needed for learners with different levels of domain knowledge in physics. The high level guidance (HLG) version included continuous animations and voice narration to guide learners, while the low level guidance (LLG) version allowed learners to progress at their own pace and provided pop-up content based on their interactions with the module. We tested these versions with students enrolled in a first-year algebra-based mechanics course. The results showed that both versions of the module were generally effective in teaching students the principles of force and motion. However, we did not find any evidence of the expertise reversal effect in that the modules did not seem to provide adaptive instruction based on students' domain knowledge levels. We will discuss possible reasons for our results and implications for creation of multimedia materials for learning.

J06-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk | Exploring Students' Modeling Behavior Around Proposing Causes for Experimental Discrepancies Using the MAPLE Assessment

Presenting Author: Rachael Merritt, University of Colorado Boulder/JILA

Additional Author | Heather J Lewandowski, University of Colorado Boulder/JILA

The Modeling Assessment for Physics Laboratory Experiments (MAPLE) is a research-based assessment instrument designed to measure student proficiency with modeling in experimental physics in upper-division electronics and optics courses. The assessment's design was informed by the Experimental Modeling Framework, which consists of iterating through five subtasks: Making Measurements, Constructing Models, Making Comparisons, Proposing Causes, and Enacting Revisions. Analysis of the electronics survey data indicate that students engage less with the Propose Causes subtask in the 'choose your own adventure' activity part of the assessment as compared to other subtasks. Here, we explore how students are interacting with the Propose Causes subtask and how this can inform laboratory instruction.

J06-03 (10:24 to 10:36 AM) | Contributed Talk | Discrete and Continuous Connections: Reflective Interview on a Computational Activity

Presenting Author: Christian Solorio, Oregon State University

Additional Author | Elizabeth Gire, giree@oregonstate.edu

To understand the connections students make between discrete and continuous systems and how computation supports those connections, we present a case study of one student. This participant took a junior-level quantum mechanics course and the accompanying computational lab course. The following year, she became an undergraduate TA for that computational lab course. In a video elicitation interview, the participant watched a video clip of herself when she was a student working on a computational activity with a partner. She was asked to reflect on her experience with the task both as a student and as a TA. From this interview, we have identified some of the challenges and affordances of using computational activities for facilitating students' connections between discrete and continuous systems. Challenges included understanding functions as arrays in the context of computation and the contextual meaning of mathematical objects like Δx.

J06-04 (10:36 to 10:48 AM Wednesday) | Contributed Talk) | The Journey of Quantitative Literacy Development: Insights from Physics Majors

Presenting Author: Qirui Guo, University of Washington

Additional Author | Charlotte Zimmerman, University of Washington

Additional Author | Suzanne White Brahmia, University of Washington

This talk will share preliminary results from an ongoing investigation of the development of quantitative literacy among physics majors through the use of the Physics Inventory for Quantitative Literacy (PIQL). The PIQL is a reasoning inventory that assesses students' quantitative skills in calculus-based introductory physics courses through upper-division courses. Through qualitative analysis of free response survey items and quantitative analysis of PIQL responses taken at different stages of majors' course-taking, we characterize features of physics quantitative literacy development of a sample of students as they progress through the physics major. This research examines the aspects of quantitative literacy in which students tend to improve, the factors that might contribute to better performance, and some implications for future pedagogy. The findings will inform a larger, ongoing research project and contribute to the understanding of how students develop quantitative literacy in the college physics curriculum, and how the instructors can foster its development.

J06-05 (10:48 to 11:00 AM Wednesday) | Contributed Talk | Using Ego Network Analysis to Probe Student Mistakes Adding and Subtracting Vectors

Presenting Author: Nekeisha Johnson, North Dakota State University

Additional Author | John B Buncher, North Dakota State University

Building on many prior studies that have looked at student ability to use vectors and vector skills like addition, subtraction, and multiplication, we use network analysis techniques to explore the relationship between students' performance on vector addition and vector subtraction questions. To facilitate this, we surveyed introductory algebra-based students using a multiple-choice assessment that prompted them to do many addition and subtraction questions of vectors in different alignments. Using ego network analysis on this multiple-choice data, in conjunction with handwritten versions of the same questions, we investigate the intersection of different student mistakes. Results of this analysis will be discussed, as well as implications for teaching.

Session J07: Supporting Women Physics Students

Location: Ballroom A08 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Deepak Iyer

J07-01 (10:00 to 10:12 AM Wednesday) | Contributed Talk | Correlating Attitudes with Persistence in Undergraduate Women

Presenting Author: Maxwell Franklin, Drexel University

Additional Author | Eric Brewe, Drexel University

Using data collected at the Conference for Undergraduate Women in Physics (CUWiP) from 2014 to 2018, as well as a follow up survey, we examine correlations between a wide range of attitudes as an undergraduate student and persistence. From our follow up survey, we can examine correlations between attitude and participation in physics through and after graduation. The CUWiP surveys asked about women's sense of community, performance competence, physics identity, physics interest, sense of belonging, and perceived recognition. Our analysis covers each individual question asked on the survey, as well as compound categories created from grouping similar questions. We find that identity, interest, and perceived recognition are correlated with persistence, while sense of belonging is anti-correlated with persistence. Our goal for this project is to find a comprehensive list of qualities that can be used to predict retention in undergraduate women. Using these qualities and future CUWiP surveys, we can find which undergraduate women need more support from the physics community.

J07-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk) | Does Groupwork Undermine Self-Efficacy in Female Physics Majors?

Presenting Author: Karen Cummings, Dept. of Physics and Astronomy, University of Waterloo, Ontario, Canada

Additional Author | Serene F Rodrigues, Dept. of Curriculum and Instruction, University of British Columbia, Canada (1)

Collaborative groupwork in physics courses is at the core of many PER informed shifts in pedagogy that are linked to improved learning outcomes. At the same time, it is not hard to imagine situations that could arise in small groups that would work to undermine the self-efficacy and comfort of particular students. We were especially concerned about this possibility at our large, male-dominated research university where women had anecdotally reported feeling unheard, dismissed, or worse during group activities in the past. In this talk we will discuss shifts in self-efficacy among physics majors during the first year. A total of about 200 students, approximately 60 of whom self-identify as females, start a physics major at our institution each fall. In 2022/2023, we measured student self-efficacy (related to being a physics major, taking the physics course and working in groups) at the start of our two-term, first-year sequence for majors. We measured self-efficacy again near the end of the two-term sequence, after many months of having students work together in groups. Changes in self-efficacy over time and differences between genders will be discussed, as will our attempts to introduce DEI materials into course-related group work.
(1) Formerly in the Department of Physics and Astronomy, University of Waterloo

J07-03 (10:24 to 10:36 AM Wednesday) | Contributed Talk | Scientific Training for Girls and Women from Rural Communities

Presenting Author: Carmen del Pilar Suarez Rodríguez, Academic Coordination of the South Huasteca Region of the Autonomous University of San Luis Potosi

In the Huasteca Potosina, a rural area with a high percentage of economic and social marginalization, where the least favored belong to the indigenous population, for more than six years they have been working on a scientific training program for girls and young women, as a way to contribute to the perception of the role of women in society, promote a taste for science, and develop projects that address the solution of local problems. Currently, phase VI of the program is being celebrated, which has been transformed according to the needs of the context and has been held in a virtual and hybrid face-to-face manner, and has passed with the pandemic from the local to the international. This presentation shares the results of the implementation of this program that has served more than 400 girls in 14 countries of America.

J07-04 (10:36 to 10:48 AM Wednesday) | Poster Roundtable | Brazilian Girls in Science Project: Active Methodologies to Reduce Gender Equality

Presenting Author: Mara Parisoto, Universidade Federal do Paraná

In 2018, an investment of 570,000 dollars was made by a government public call with the objective of supporting projects aimed at stimulating the training of women for the careers of exact sciences, engineering and computing in Brazil. This call was also focused on arousing the vocational interest of female students from Basic

Education to Higher Education by these professions and for scientific and technological research. This action aims to combat the dropout, common in the first years of undergraduate courses in these areas, as well as bringing public schools closer to Basic Education and Higher Education Institutions. Another objective is to attract more girls to pursue careers in the exact fields (which are primarily male), which would increase gender equality and potentially increasing the quality of research in Brazil. In 2018, 78 projects were approved with financial resources, proposed by public/private universities, museums and non-governmental organisations from all regions of the country. Thus, in 2020, approximately 40 other projects with financial resources were contemplated. These projects are proposed to reduce, in the coming years, the horizontal and vertical exclusion in the areas covered by the project and a significant advance in Brazilian science.

Session J08: Teamwork in Labs: Guidance for Instruction

Location: Ballroom A09 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Danny Doucette

J08-01 (10:00 to 10:12 AM Wednesday) | Contributed Talk | Investigating Approaches for Supporting Communication Skills to Foster Students' Physics Identity Development and Sense of Belonging

Presenting Author: Anne Leak, Center for Science and Engineering Partnerships, UC Santa Barbara

Co-presenting Author | Jyllian Herman, High Point University

Additional Author | Peter Chung, University of Southern California

Additional Author | Chris Vaca, Rio Hondo College

Asking questions and making contributions is paramount to getting recognized as a STEM person, yet students from underserved backgrounds are often afraid to ask or share ideas at risk of portraying a negative identity for themselves, and even entire groups they identify with. The TRAINS project supports physics URM transfer students in navigating cultural interfaces and the transition from a community college to a baccalaureate-granting institution. This study uses qualitative data from a focus group and journaling prompts on expectations and experiences asking questions, communicating, and making research contributions in their fields. Data was collected from four TRAINS community college students during a lab course following their summer research experience. Analysis included emergent and semantic coding to explore students' perceived participation and sense of belonging. Preliminary results show that as students become more established in their physics identity they ask more questions, which is informed and validated by making contributions in the field. These findings suggest strategies mentors can use to support students' identities and sense of belonging, such as finding ways students can actively contribute early in their college career as well as openly encouraging their students to ask questions as part of labs and research experiences.

J08-02 (10:12 to 10:24 AM Wednesday) | Contributed Talk | Teaching Practices to Build Classroom Community and Team Work in a Lab Setting

Presenting Author: Annie Chase, Physics Dept. San Jose State University

Co-presenting Author | Andrew Totah-McCarty, Physics Dept. San Jose State University

A key component of collaboration is the willingness of the individual to share their ideas. We believe students are more likely to share their ideas about physics when the environment is free from judgment, welcomes students to participate as their whole selves, and recognizes students' ideas as valuable regardless of their "correctness". We present the ways in which we strive to create such an environment in a first semester, algebra-based physics "Discussion Lab," a reformed lab where students work collaboratively in small groups observing phenomena and using models to explain what they see. Instructors facilitate small group conversations as well as whole class discussions where the goal is to help students synthesize their ideas and develop a class consensus response. Our practices include starting the day with "Community Builders," wearing name tags with pronouns, and providing the students with a "Discussion Lab Framework" to support both small group and whole class interactions. We also share student feedback about these practices.

J08-03 (10:24 to 10:36 AM Wednesday) | Contributed Talk | Partner Agreements and Equitable Role Distributions in Labs

Presenting Author: Matthew Dew, Cornell University

Additional Author | Emma Hunt, The University of Texas at Austin

Additional Author | Andrew Loveridge, The University of Texas at Austin

Additional Author | Viranga Perera, The University of Texas at Austin

Additional Author | Jonathan Perry, The University of Texas at Austin

Additional Author | Gregorio Ponti, The University of Texas at Austin

In physics lab courses, students are required to engage in a variety of different tasks, including using equipment, taking notes, analyzing data, and managing group members. Involvement in these activities allows students to gain competence and familiarity with each component of the scientific process. However, there is a growing body of evidence that these tasks are not shared in equitable ways among group members with students often adopting roles within groups that are influenced by their demographic identity, including gender. To remediate this effect, we implemented an intervention which tasked students with completing partner agreement forms each week. These forms included instructions to have explicit conversations about role distribution among group members. We coded video recordings of four introductory physics lab sections – half of the sections assigned with partner agreements and half treated as control groups – to assess the effectiveness of the intervention. We find mixed results, with the intervention effective in some cases but not in others. Our results can inform instructors of the effects of partner agreement forms on division of labor in lab courses.

J08-04 (10:36 to 10:48 AM Wednesday) | Contributed Talk | Exploring Teamwork in a Physics Course-Based Undergraduate Research Experience: Goals, Challenges, and Strategies

Presenting Author: Alexandra Werth, University of Colorado Boulder

Additional Author | Kristin A. Oliver, University of Colorado Boulder

Additional Author | Colin G. West, University of Colorado Boulder

Additional Author | Heather J. Lewandowski, University of Colorado Boulder

In this study, we examine how teamwork is fostered in a physics course-based undergraduate research experience (CURE) designed to emphasize teamwork as a scientific practice. We used data from an adaptive questionnaire on regulation of emotions (AIRE) and students' written memos to future researchers to understand students' teamwork goals, challenges, and strategies from the perspective of socially shared regulation of learning. Our findings indicate that students were successful

in achieving their teamwork goals largely by employing socially shared regulatory strategies to overcome obstacles. Additionally, students recognized the importance of teamwork in their research experience. These findings have implications for the design of future CUREs and lab courses, as well as for instructors seeking to assess teamwork in their own courses.

Session J09: Some Interesting Bauder Fund Projects

Location: Ballroom A10 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Thomas O'Kuma

J09-01 (10:00 to 10:24 AM Wednesday) | | NJAAPT in Action: Honoring the Bauders Legacy

Presenting Author: James Ferrara, Bernards High School, Bernardsville, NJ

Additional Author | Debbie Andres, Paramus High School, Paramus, NJ

The Bauder Fund is managed by the AAPT and is available to any affiliated organization through a bi-annual grant funding process. The legacy of the Bauders has deep ties in NJ therefore giving the NJ Section unique access to the funds. In this presentation, the history of the Bauder Fund and its ties to the New Jersey Section will be illuminated along with many of the ways the section has utilized funds over the past two-plus decades in support of physics teachers and physics teaching in our state. We've had great success with make-and-takes, Physics Olympics events, dinner meetings, and demo shows, just to name a few. Many examples will be shared to show how the Bauder Fund has enhanced both the success of supported events and the experience of the attendees.

J09-02 (10:24 to 10:48 AM Wednesday) | | Several Intriguing Ways to Effectively Use Bauder Funds

Presenting Author: Samuel Sampere, Syracuse University

We have received numerous Bauder Fund awards in the last few decades (yeah....). Some of these were solely to provide science toy handouts to the public, while others helped put rather expensive apparatus in teachers' hands through make-and-take workshops. AAPT has been a valuble facilitator, helping teachers gain much needed hands on experience. During this talk, I will describe some of these activities, especially the humerous learning outcomes for teachers.Hint: can you wire a plug, a switch, and a coil? Seems simple on paper, but when handed real world materials, it's just not that straightforward.

Session J10: Being a Student-Ready Physics Class – II

Location: Ballroom A11 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Danielle Maldonado

J10-01 (10:00 to 10:12 AM Wednesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | My Endeavors to Design Interactive and Inclusive Introductory Physics Courses

Presenting Author: Amin Bayat Barooni, Georgiaa State University

There are challenges in making physics courses more interactive and inclusive, especially in diverse environments. After two years of teaching introductory courses at Georgia State University using research-based pedagogies, I have experienced successes and challenges. I have utilized is flip teaching, along with strategies such as communicating physics, universal design, and Social-Belonging Intervention [1]. In fact, the American Association of Physics Teachers (AAPT) lab committee published a recommendation in 2014 that emphasized six focus areas, with communicating physics being one of them [2]. Communication involves generating and presenting results and thoughts using various representations. I emphasize communication skills through class and group discussions, by utilizing Think/Pair/Share [3],and interactive lecture demonstrations [4]. These skills are important for students' future careers and also aid in better understanding of physics concepts. Furthermore, I have implemented Just-In-Time Teaching (JiTT) [5], which has had a significant impact on in-class activities. I have also incorporated different features of universal design to create a more inclusive classroom environment, facilitating class discussions to foster a supportive atmosphere that encourages students to listen to each other's ideas without judgment. I have evaluated the effectiveness of these methods through various assessment tests, student evaluations and feedback.
1) Yeager, D. S., Walton, G. M. (2011). Social-psychological interventions in education: They're not magic. Review of Educational Research, 81(2), 267-301.
2) Kozminski, J., Lewandowski, H. J., Beverly, N., Lindaas, S., Deardorff, D., Reagan, A.,Hobbs, R. (2014). AAPT recommendations for the undergraduate physics laboratory curriculum. AAPT: College Park, MD, USA. 3) Gok, T. (2018). The evaluation of conceptual learning and epistemological beliefs on physics learning by think-pair-share. Journal of Education in Science, Environment and Health, 4(1), 69-80. 4) Sokoloff, D. R., Thornton, R. K. (1997). Using interactive lecture demonstrations to create an active learning environment. The Physics Teacher, 35(6), 340-347. 5) Novak, Gregor M and Patterson, Evelyn T and Gavrin, Andrew D and Christian, Wolfgang. (1999). Just in time teaching. American Association of Physics Teachers.

J10-03 (10:24 to 10:36 AM Wednesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Making Physics for All a Reality

Presenting Author: Robert Goodman, New Jersey Center for Teaching and Learing

Uneven student proficiency in mathematics has long been seen as an obstacle to teaching Physics to All. Tracking students with poor mathematical backgrounds away from physics, or to lower-level physics, exacerbates inequitable access to quality education and, eventually, to colleges and careers. Pandemic shutdowns only worsened the problem as differences in mathematical proficiency between students from affluent, better-educated families and those without that support widened The answer is not to lower the level of physics being taught, or to fall back on tracking. The answer is to double down on techniques that have proven effective in creating a welcoming, rigorous environment that works for all students These proven techniques address the needs of students with weak prior backgrounds even while students with strong backgrounds advance at a faster pace than they would have in an "advanced track" class. They include the use of formative assessment with anonymous polling; promoting social constructivist interaction through group seating; after-school clubs with peer tutoring; mastery grading via retests, and AP-level testing and scoring. Participants should bring a laptop so they can review the free, editable materials posted at njctl.org that support these approaches and discuss them in small groups.

J10-04 (10:36 to 10:48 AM Wednesday) | Contributed Talk | Encouraging a Growth Mindset

Presenting Author: Chuck Winrich, Babson College

Making a course equitable, accessible, and student-ready includes convincing the students that the course is accessible to them. This can be challenging in college courses where students already perceive themselves as not skilled in a particular area (such as physics) based on their high school experiences. Dweck referred to this

as a fixed mindset – a general belief that intelligence is pre-determined. A growth mindset – the general belief that intelligence can be developed – has been linked to greater motivation, enjoyment of learning, and achievement. In this talk, I will present activities that I use to encourage a growth mindset in an introductory science class on electronics at Babson College. I will include some samples of student work and feedback gathered from course evaluations.

Session J12: JNIFPER Roundtable

Location: Meeting Room 03 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Kathleen Hinko

J12-01 (10:00 to 11:00 AM Wednesday) | Interactive (e.g. panel, round table discussion, hands-on activity) | Joint Network for Informal Physics Education & Research (JNIPER) Panel Discussion

Presenting Author: Kathleen Hinko, Michigan State University

Co-presenting Author | Jessica Hoehn, University of Colorado Boulder

Additional Author | Michael Bennett, University of Colorado Boulder

Co-presenting Author | Alexandra Lau, American Physical Society

Additional Author | Claudia Fracchiolla, American Physical Society

Additional Author | Noah Finkelstein, University of Colorado Boulder

Informal physics education, also referred to as outreach or public engagement, benefits the public, science and scientists, as well as the institutions to which we belong. The Joint Network for Informal Physics Education & Research (JNIPER) is a community of practice for those involved or interested in designing, facilitating, or studying informal physics learning activities and programs. JNIPER seeks to provide training, resources, connection, and advocacy for public engagement in physics, thereby reducing the isolation and disconnection often experienced in informal physics education work. In this interactive session, we will introduce the network, hear from invited panelists about their informal physics education activities and research, and engage in a discussion about how a network such as JNIPER can support the public engagement work of the community.

Session J13: Panel: Evolution of AAPT Lab Recommendations

Location: Meeting Room 04 **Sponsor:** AAPT **Time:** 10–11 a.m. **Date:** Wednesday, July 19, 2023 **Presider:** Nancy Beverly

Danielle Buggé

AWARDS: PhysTEC Teacher of the Year Award Talk – Danielle Buggé

The 2022 National Teacher of the Year is Danielle Buggé of West Windsor-Plainsboro High School South in Princeton Junction, NJ. Buggé was nominated by PhysTEC institution Rutgers University, from which she graduated.
Throughout her 13-year career, Buggé has created an environment where students develop confidence in science, communication, and collaboration. From her dedication to students and the teaching of physics, many successes followed.

Wednesday, July 19
11 a.m.–12 p.m.
Ballroom A01

Rachel Ivie

PLENARY: Diversity in Physics and Astronomy Update – Rachel Ivie

Beyond Representation: Data to Improve Equity in Physics and Astronomy

The American Institute of Physics (AIP) collects data on the representation of women and members of other underrepresented groups in physics and astronomy at all levels, from high school students to faculty members. Although indicative of some trends, these data do not tell the whole story. For physicists and astronomers who persist despite being underrepresented, data show that there are additional barriers to equitable participation. For example, women physicists who responded to a global survey reported that they have less access to career-advancing resources than men reported. In addition, AIP's TEAM UP report documents factors that contribute to the low numbers of Black undergraduate students in physics and astronomy. A recent AIP study of the effects of COVID on undergraduate physics and astronomy students showed more negative effects for those who are from marginalized groups than for those who are not marginalized. The effects of barriers such as these combine to create an accumulation of disadvantage that can set back individual scientists' careers and impede scientific progress. Data on inequity in physics and astronomy are essential so that we may design programs and practices that will allow full participation for all.

Session: Bridging Plenaries and PERC Kickoff
Location: Ballroom A01 **Sponsor:** AAPT **Time:** 4–4:45 p.m. **Date:** Wednesday, July 19, 2023 **Presider:** TBA

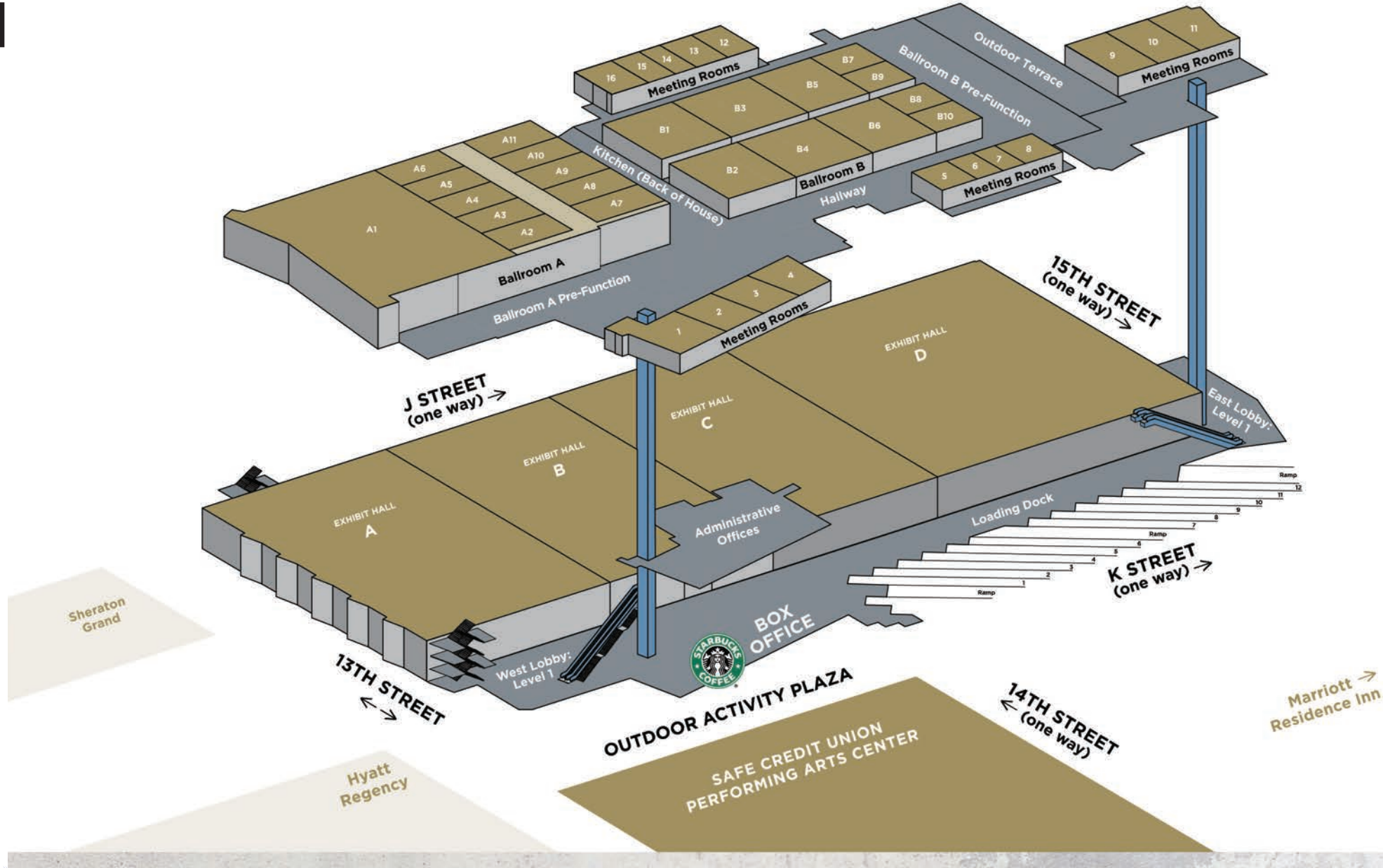
Speakers: Dean Zollman and Ximena Cid

Session: PERC - Poster Session 1
Location: Ballroom A01 **Sponsor:** AAPT **Time:** 5–6:15 p.m. **Date:** Wednesday, July 19, 2023 **Presider:** TBA

Presenters with odd-numbered posters will present during the first 35 minutes.
Following a 5-minute transition period, presenters with even-numbered posters will present during the last 35 minutes.

Session: PERC - Plenary 1
Location: Ballroom A01 **Sponsor:** AAPT **Time:** 8:30–9:30 p.m. **Date:** Wednesday, July 19, 2023 **Presider:** TBA

Speakers: W. Brian Lane, Mary Urquhart, Kris Lui, and Nekeisha Johnson



SAFE CREDIT UNION | CONVENTION CENTER

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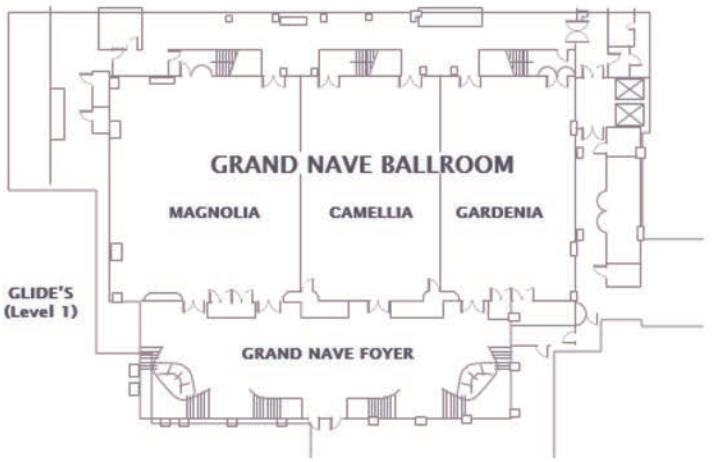
Sheraton Grand Hotel floor plan

SHERATON GRAND
Sacramento Hotel

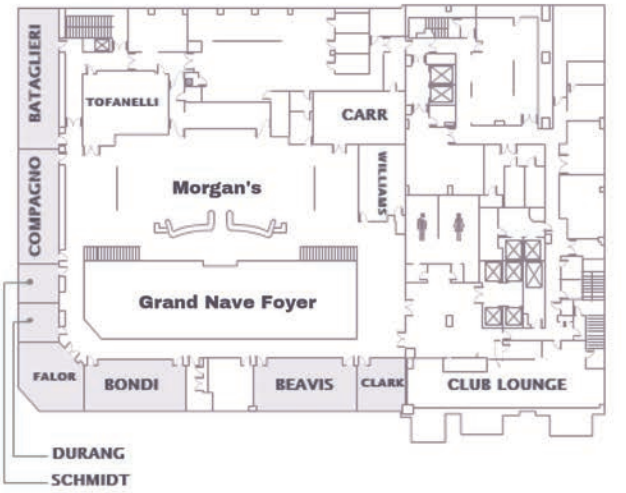
Lower Level



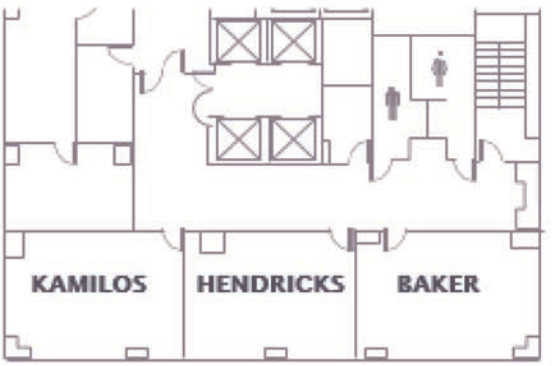
Lobby Level

Public Market Bar
Glide's Event Space

Level 2

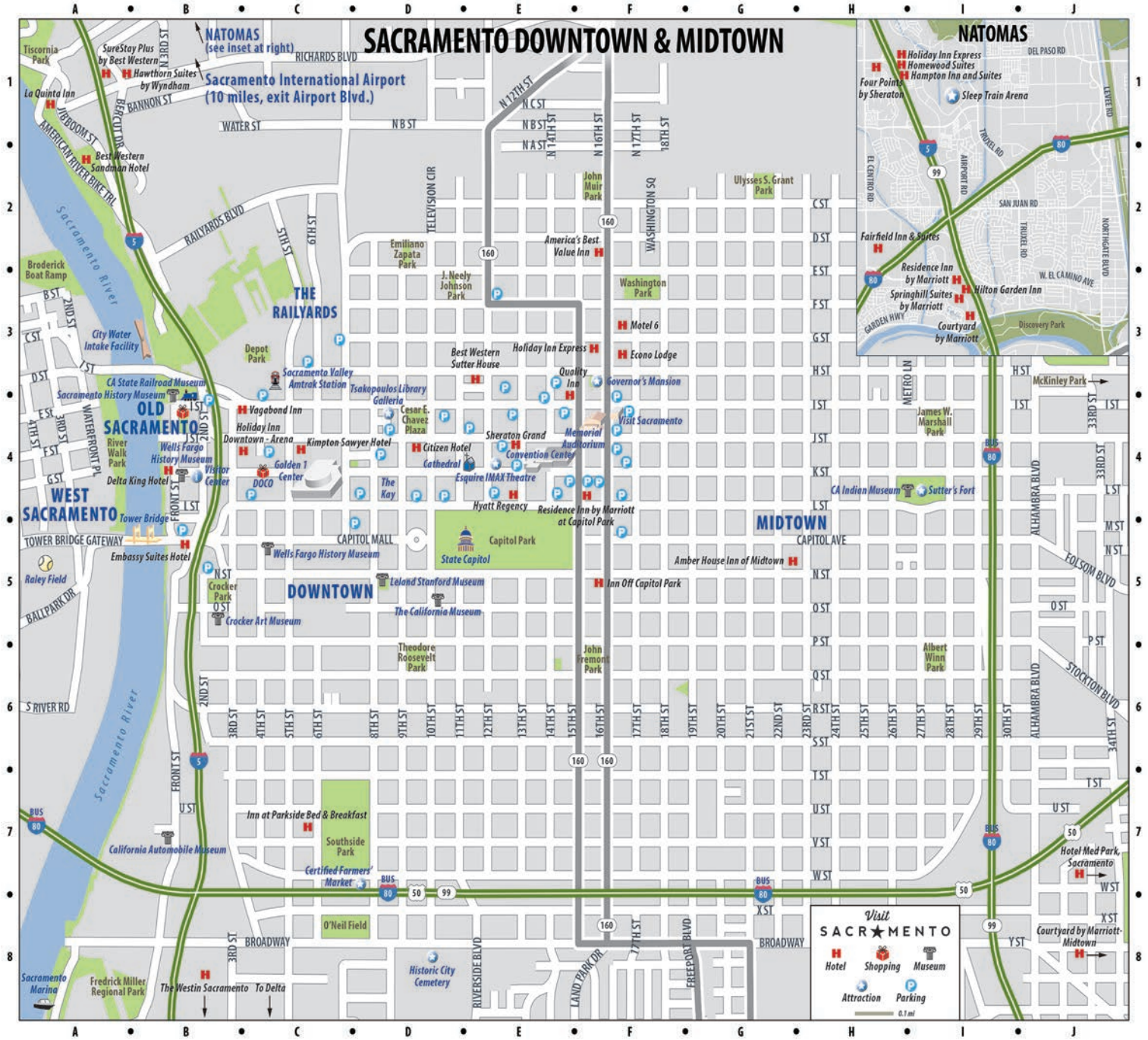


Level 3



Level 4

Sheraton Fitness
Swimming Pool
Executive, Sales & Events Office


SACRAMENTO DOWNTOWN & MIDTOWN
NATOMAS
(see inset at right)
Sacramento International Airport
(10 miles, exit Airport Blvd.)
THE RAILYARDS
OLD SACRAMENTO
WEST SACRAMENTO
DOWNTOWN
MIDTOWN
Capitol Park
State Capitol
Sacramento River
Tiscornia Park
La Quinta Inn
SureStay Plus by Best Western
Hawthorn Suites by Wyndham
Best Western Sandman Hotel
Broderick Boat Ramp
City Water Intake Facility
Depot Park
CA State Railroad Museum
Sacramento History Museum
Sacramento Valley Amtrak Station
Vagabond Inn
Holiday Inn Downtown - Arena
Kimpton Sawyer Hotel
River Walk Park
Wells Fargo History Museum
Visitor Center
Golden 1 Center
DOCO
Delta King Hotel
Tower Bridge
TOWER BRIDGE GATEWAY
Embassy Suites Hotel
Raley Field
BALLPARK DR
Crocker Park
Crocker Art Museum
Wells Fargo History Museum
Leland Stanford Museum
The California Museum
Theodore Roosevelt Park
Tsakopoulos Library Galleria
Cesar E. Chavez Plaza
The Kay
Citizen Hotel
Cathedral
Sheraton Grand
Convention Center
Esquire IMAX Theatre
Hyatt Regency
Residence Inn by Marriott at Capitol Park
Memorial Auditorium
Visit Sacramento
Governor's Mansion
Quality Inn
Best Western Sutter House
Holiday Inn Express
Econo Lodge
Motel 6
America's Best Value Inn
Emiliano Zapata Park
J. Neely Johnson Park
John Muir Park
Washington Park
Ulysses S. Grant Park
Inn Off Capitol Park
Amber House Inn of Midtown
John Fremont Park
Albert Winn Park
James W. Marshall Park
McKinley Park
CA Indian Museum
Sutter's Fort
Inn at Parkside Bed & Breakfast
Southside Park
Certified Farmers' Market
O'Neil Field
California Automobile Museum
Historic City Cemetery
Sacramento Marina
Fredrick Miller Regional Park
The Westin Sacramento
To Delta
Hotel Med Park, Sacramento
Courtyard by Marriott-Midtown
Holiday Inn Express
Homewood Suites
Hampton Inn and Suites
Four Points by Sheraton
Sleep Train Arena
Fairfield Inn & Suites
Residence Inn by Marriott
Springhill Suites by Marriott
Hilton Garden Inn
Courtyard by Marriott
Discovery Park
Visit SACRAMENTO
Hotel
Shopping
Museum
Attraction
Parking
0.1 mi