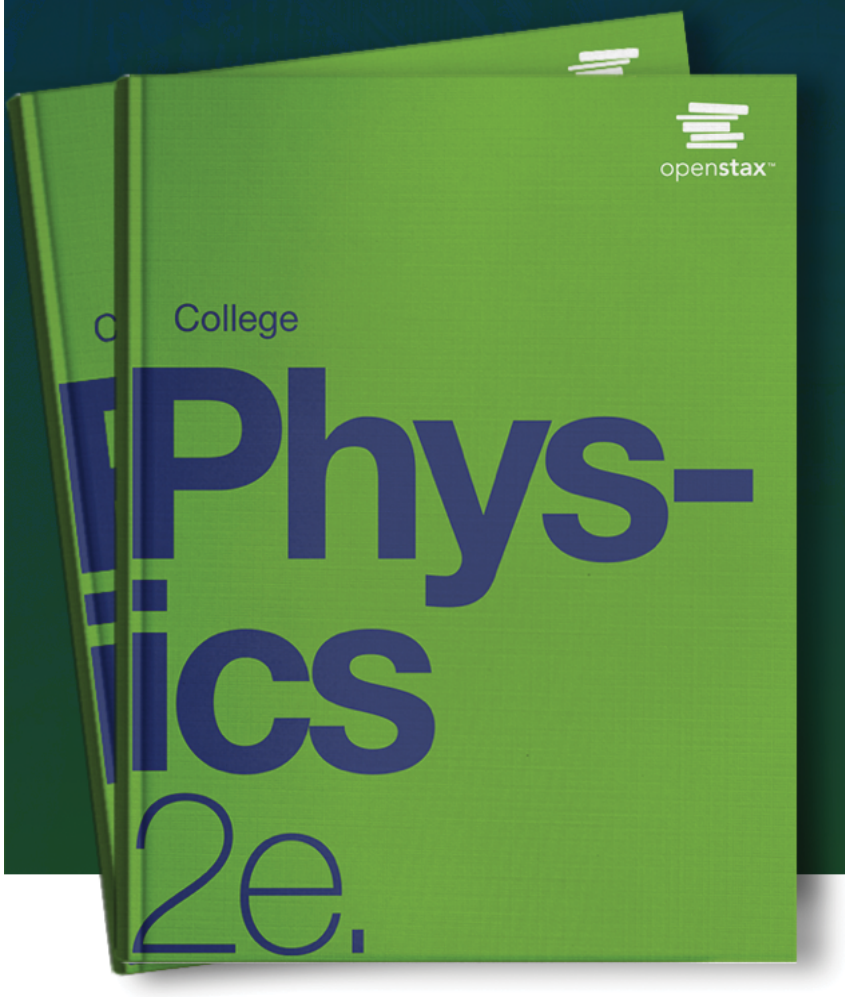
2022 AAPT
SUMMER MEETING
GRAND RAPIDS, MICHIGAN, JULY 9 - 13

AAPT
PHYSICS EDUCATION



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GREATER CONTENT

Lunch & Learn
Grand Gallery D
12 PM–1 PM
Monday 7/11/22

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. Now, our newest initiative is building a turn-key solution for shared materials that are assignable and automatically-graded. In 2021, we launched a problem-authoring tool for instructors and as of now our platform houses over 17,000 user-authored questions, and instructors have pledged to share over 9,000 of these with the community. We are exited to launch a new era of Expert TA where instructors can leverage the valuable academic excercises created by this community.

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Booth 200

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Special Thanks

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

Workshop Organizer: Brad Ambrose

Program Chair: Duane Merrell

Meeting Structure Committee: Jon Anderson, Alice D. Churukian, Elaine Gwinn, Jan Landis Mader, Duane B. Merrell, Adebanjo Oriade, Toni Sauncy, Brad R. Conrad, Ex Officio, Tiffany M. Hayes, Ex Officio

Wifi Code at Devos Place Convention Center:

User name: **AAPT**
Password: **AAPT2022**

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Contact:

Meeting Registration Desk: 301-209-3340

Facebook/Twitter at Meeting

We will be posting updates to Facebook and Twitter prior to and during the meeting to keep you in the know! Participate in the conversation on Twitter by following us at **twitter.com/AAPTHQ** or search the hashtag **#aaptsm22**. 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
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Committee Meetings

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

Sunday, July 10

Meetings Locations Committee	8–10:15 a.m.	H: Pantlind Ballroom
Section Officers and Representatives	5–6 p.m.	CC: River Overlook A/B
Nominating Committee I	6–7 p.m.	CC: River Overlook A/B

Monday, July 11

Graduate Education in Physics *	7–8 a.m.	CC: Grand Gallery F
History and Philosophy of Physics *	7–8 a.m.	H: Haldane
Laboratories Committee *	7–8 a.m.	CC: River Overlook E
Research in Physics Education *	7–8 a.m.	CC: Grand Gallery F
Awards Committee	12–1 p.m.	H: Berkey
Apparatus Committee *	12–1 p.m.	CC: Grand Gallery F
Contemporary Physics Committee *	12–1 p.m.	CC: Grand Gallery Overlook H
International Physics Educ. Committee *	12–1 p.m.	H: Thornapple
Professional Concerns Committee *	12–1 p.m.	CC: River Overlook E
Physics in Pre-High School Education *	12–1 p.m.	H: Nelson
Diversity In Physics Committee *	5–6 p.m.	H: Haldane
Physics in High Schools Committee *	5–6 p.m.	CC: Grand Gallery B
Physics in Undergrad. Educ. Committee *	5–6 p.m.	CC: River Overlook A/B
Science Education for the Public *	5–6 p.m.	CC: River Overlook C
Teacher Preparation Committee *	5–6 p.m.	CC: River Overlook E
Interests of Senior Physicists Committee*	5–6 p.m.	CC: Grand Gallery C
PERLOC Committee (closed)	5–6 p.m.	H: Thornapple
PIRA Committee *	5–6 p.m.	CC: Grand Gallery Overlook C/D

Tuesday, July 12

Nominating Committee II	7–8 a.m.	CC: River Overlook A/B
Physics Bowl Advisory Committee	7–8 a.m.	H: Berkey
PTRA Oversight Committee	7–8 a.m.	CC: Grand Gallery F
Safe Solar Observing Share-A-Thon	12–1 p.m.	CC: Atrium
Physics in Two-Year Colleges Committee*	5:30–6:30 p.m.	CC: Grand Gallery B
Women in Physics Committee *	5:30–6:30 p.m.	CC: Grand Gallery Overlook A/B
Educational Technologies Committee*	5:30–6:30 p.m.	CC: River Overlook C
PERTG Town Hall *	5:30–6:30 p.m.	CC: River Overlook E
Space Science & Astronomy Committee *	5:30–6:30 p.m.	CC: Grand Gallery E
Membership and Benefits Committee	5:30–6:30 p.m.	H: Haldane

Wednesday, July 13

Committee on Governance Structure	7:30–9 a.m.	H: Pantlind Ballroom
Membership and Benefits	7:30–9 a.m.	H: Haldane
Programs Strategic Planning	7:30–9 a.m.	CC: River Overlook A/B
Venture/Bauder Fund Committee	7:30–9 a.m.	H: Berkey

Debbie Stephanie Andres Named as 2022 Recipient of the Doc Brown Futures Award

Debbie Andres

The 2022 recipient of the Doc Brown Futures Award is Debbie Andres. The Doc Brown Futures Award recognizes early-career members who demonstrate excellence in their contributions to AAPT and physics education and exhibit the potential to serve in an AAPT leadership role. The award will be presented during the 2022 Summer Meeting.

"I am incredibly grateful to be the recipient of this award. The members of AAPT have helped me grow as a physics educator and encouraged me to lead and share my voice. I hope to continue to help this organization grow by introducing more high school teachers to the many opportunities AAPT has given me," said Andres.

A member of AAPT since 2015, she earned a B.S. in Mechanical Engineering and EdM in Science Education K-12 at Rutgers University, New Brunswick, NJ. Andres was a Learning Assistant (LA) before she started a physics teacher preparation program and then a mentor for LAs. While in the graduate program, she continued to work with peer leaders in the Rutgers Learning Centers, foreshadowing what would be her future work as a teacher leader in her current school district. She worked with the NJ Governor's School of Engineering and Technology and created the 3-week (12 lessons) course "Exploring Packaging Engineering Using Solidworks" for a class of 15 high school level students. She taught beginner students skills in Solidworks needed for 3D modeling, sheet metal, and animation. She collaborated with the Packaging Engineering department to show students the importance of modeling and the engineering design process in the packaging engineering industry.

Finding My Physics Teaching Family

Monday July 11

11 a.m–12 p.m.

Hotel: Ambassodor Ballroom

After graduating from the teacher preparation program in 2016, Andres accepted a position at Paramus High School, a public high school in Paramus, NJ. At the time, Paramus High School was revamping their freshmen physics courses and looking to start a new AP Physics 2 course. Upon being hired, she immediately went to work on developing the multiple freshmen physics curricula (College Prep and Honors) and starting an AP Physics 2 course from scratch. She quickly rose as a teacher leader in her community and was hired for an in-school position as an Instructional Technology Coach in October 2017. As a coach, she worked directly with staff on how to incorporate technology into their teaching practices. This position proved to be very critical as the district transitioned towards implementation of the Google Apps for Education. In September 2020, she was appointed as an Instructional Coach and worked on supporting classroom teachers in the delivery of instruction that employs best practices, instructional models, and strategies for engaging students. Andres has a great deal of professional development outside the teacher preparation program and outside of her school district. She has regularly attended workshops and sessions at the American Association of Physics Teacher (AAPT) national meetings since the Summer 2015. During her graduate program, she attended the PRISM workshop (at Montclair State University) NGSS Classroom Practices, Noyce Northeast NYC at the American Museum of Natural History, and Physics Union Mathematics Workshops. She is currently a member of multiple organizing committees of the AAPT. She is an active AAPT member of the Bauder Fund Committee and the Membership and Benefits Committee. She is currently the Chair of the National Nominating Committee and the Committee on Physics in High Schools. She also operates as the NJ Section Representative. As a board member of NJAAPT, Debbie regularly organizes professional development workshops for Physics teachers in New Jersey. During this past academic year, the workshops have been over video conferences and she has continued to help lead them and help physics teachers all around New Jersey acclimate to this virtual environment.

In addition to teaching experience, Andres has a large amount of research experience. In the summer of 2013, she applied and received funding for doing research at Harvard University School of Engineering and Applied Sciences. She investigated "Optical Properties and Durability Studies of Elastic Nanostructures" with Postural Doctorate Ximin He and its application as a banknote anti-counterfeiting method, she collaborated with Dr. David Kaplan at Tufts University on the uses of the silk fibroin, and she investigated and tested the mechanical properties of various compounds. She is currently working on a research project at Rutgers that is focusing on "Exploring the relationship between perceived and predicted explanation value". Andres led her cohort in numerous creative endeavors, such as attendance at AAPT meetings, teaching workshops for high school students, preparation of a physics show for Rutgers Day and many others. She was the heart and soul of her cohort, loved and respected equally by peers and professors.

Robert William Brown (Distinguished University and Institute Professor in the physics department at Case Western Reserve University) has had a rewarding five-decade career in teaching, research, and entrepreneurship. An Inaugural Fellow of the AAPT, Doc Brown is associated with a number of educational innovations, including an early use of a fiberoptics electronic educational environment (1980s), of an early use of undergraduate teaching assistants (1990s), of published PER work on both "post-exam syndrome" and its treatment, and "cycling" or structured revisiting of classroom material. His teaching led to the writing of a thousand-page MRI textbook, which has been called the "daily companion of the MRI scientist." Doc Brown has received five regional national teaching honors on his innovations in undergraduate and graduate teaching, and in 2004 received the AAPT Excellence in Undergraduate Physics Teaching National Award. A partnership with his wife, Janet Gans Brown has taken them to highlight the importance of AAPT in a shared life and their gratitude by this endowment.

2022 Lillian McDermott Medal Awarded to Wolfgang Christian

Wolfgang Christian

The Promise and Impact of Computation for Teaching

Monday, July 11

2:30–3:30 p.m.

Hotel: Ambassador Ballroom

Wolfgang Christian will receive the Lillian McDermott Medal. This award recognizes those who are passionate and tenacious about improving the teaching and learning of physics and have made intellectually creative contributions in this area.

Christian, Brown Professor of Physics Emeritus at Davidson College, is probably best known for his development of the high-quality interactive computer-based resources, Physlets and Open Source Physics (OSP), which are freely available to all teachers and students on the AAPT ComPADRE digital library.

Regarding his receipt of the McDermott Medal, Christian said, "I am honored and humbled to receive the first Lillian McDermott Medal. The work that the Open Source Physics team has done using computation to help students overcome conceptual difficulties rests on the Physics Education Research foundation that Lillian helped build. We all stand on the shoulders of giants and Lillian was indeed a giant."

Christian received his B.S. and PhD from North Carolina State University. He began his career as an Assistant Professor teaching at Mercyhurst College, Allegheny College, and Earlham College before moving to Davidson College in 1983 where he was appointed to various positions, including Davidson Physics Computation Center Director, Professor, Physics Department Chair, and Brown Professor of Physics.

In 2006 he was named an APS Fellow, being cited "For his years of dedication and significant contributions to the use of computers in undergraduate physics education, especially for his creation, design and effective use of interactive curricular materials." In 2009 the Southeastern Section of APS recognized him with the Pegram Award for Excellence in the Teaching of Physics. He served as the APS Forum on Education Vice-Chair, Chair-Elect. Chair, and Past-Chair. From 2001-2004 he chaired the APS Ad-Hoc committee to establish the APS Excellence in Physics Education Award and he and Fred Stein raised over $100,000 to endow that award.

In 2003 AAPT recognized Christian's service with the Homer L. Dodge Citation. He was a founding member of the North Carolina Section of AAPT in 1996 and served in the Section's presidential chain from 2009 throuHi2012. In 2013 he was elected to the AAPT Board of Directors as Secretary. In that role he served as chair of the Publications Committee, and as member of the Award, Venture Fund, and Governance Structure Committees. He was named a Fellow of the American Association of Physics Teachers in 2014.

Christian has had a huge impact on the physics education community and has helped usher in computational physics in high school, undergraduate, and graduate education around the country and the world. He worked with Harvey Gould and Jan Tobochnick on the third edition of An Introduction to Computer Simulation Methods and he developed the OSP code library for that book. He and two of his colleagues who developed Physlets (Mario Belloni and Anne Cox) worked with both the Two-Year College (TYC) Workshop Project and the Advanced Technology Education Physics Workshop Project. This collaboration started in 2001 and is ongoing. In 2011 Open Source Physics and the AAPT-ComPADRE team lead by Bruce Mason and Lyle Barbato were awarded the AAAS Science Prize for Online Research in Education (SPORE) for "the development of online tools that bring interactive computer-based modeling to students at many levels." In 2020 the 18 members of Open Source Physics collaboration were recognized by the APS with the Excellence in Physics Education Award. The team was cited, "For sustained commitment to computational physics education through creating and disseminating programming environments, books, software, simulations, and other tools to support computational thinking, and for research establishing the value of these tools and best practices for their use."

Christian's OSP team collaborated with Gay Stewart and the College Ready in Mathematics and Physics Partnership (CR-MSP) and with Tom O'Kuma and Dwain Desbian on the Two Year College (TYC) project in multi-day workshops providing many hours of training in OSP developed materials. The weeklong CR-MSP workshops introduced Arkansas in-service teachers to OSP simulations and video analysis tools and the TYC workshops engaged 280 high school and two-year college physics faculty participants (20 per workshop) from many different institutions in different states around the country. Each workshop participant used the OSP materials to develop curricular materials that they would use in their classes. They then presented their developed lesson/lab/simulation to the rest of the participants for suggestions. All developed lessons/labs/simulations were electronically captured and given to all participants.

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

Andres R. Torres

Thoughts on Teaching and Motivating Students While Implementing a StepUp for Physics Curriculum

Tuesday, July 12

2:30–3:50 p.m.
Hotel: Ambassador Ballroom

Andres R. Torres to Receive 2022 Paul W. Zitzewitz Excellence in K-12 Teaching Award

The 2022 Paul Zitzewitz Excellence in K-12 Physics Teaching Award winner is Andres R. Torres, a Physics, and Environmental Management and Research teacher at Ronald Reagan/Doral Senior High School. 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.

Regarding his selection for this award Torres said, "I am deeply humbled and moved to learn that I have been chosen to receive the Award of Excellence in K-12 Physics teaching. I am thankful for all the support received in my years as a Physics teacher."

Educated in Cuba he got his Bachelor's Degree at Central University in Electrical Engineering, Automatic Control. He earned a degree in Physics and Astronomy at Felix Varela Superior Pedagogical Institute. He began teaching physics at Ronald Reagan/Doral Senior High School in 2006. Torres has sponsored the National Science Honor Society Physics (since 2011) and Engineering groups (since 2006). In 2013-2014 he participated in the study led by Dr. Zahra Hazari, Associate Professor in the Department of Teaching and Learning and the STEM Transformation Institute as well as an affiliate faculty member in the Department of Physics at Florida International University. The research focused on reforming physics learning environments to improve critical educational outcomes for under-represented groups in physics, especially women.

In 2016 he became STEM School Designation liaison, a program that promotes STEM education and integration. He also became a Master Teacher in the StepUp for Women in Physics program. He has also served as in FIU teach as a Mentor Teacher for undergraduate Physics students and as a member of the Physics Book selection committee for Miami Dade County Public Schools. Based on his success, the STEP UP 4 Women Project Management Team at the AAPT, APS, and FIU, enlisted Mr. Torres to become a Master Teacher advising the project in developing and testing curriculum designed to increase the engagement of young women in high school physics classes.

Torres has gained the respect of his colleagues, parent organizations, student body, and school staff as well as the community-at-large who readily acknowledge and recognize him as a constructive force for educational reform. He gives freely of his personal time to ensure all the educational needs of his community are met serving as the STEAM Leader, Engineering Club Sponsor, Badminton Coach, Swimming Coach, and a member of the Curriculum Council Team.

His students enter the Florida International University's undergraduate program from Ronald Reagan/Doral Senior High School not only well prepared in their physics learning but also engaged and excited to learn. This is important because one of the hardest aspects of teaching physics is getting students, particularly those traditionally marginalized in physics, excited about the content and empowered to learn more.

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 K-12 Physics Teaching recognizes outstanding achievement in teaching pre-college physics.

Sean J. Bentley to Receive the AAPT 2022 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching

Sean J. Bentley

Sean J. Bentley will receive the 2022 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching. This award is given in recognition of contributions to undergraduate physics teaching and awardees are chosen for their extraordinary accomplishments in communicating the excitement of physics to their students. John Wiley & Sons is the principal source of funding for this award, through its donation to the AAPT.

Regarding his selection for this award, Bentley said, "Teaching is my passion, so being recognized by my peers in an organization that genuinely values teaching is a great honor. The past two years have emphasized the point that effective teaching is a constantly moving target, and this award provides me with encouragement to keep growing and evolving as an educator. If I can be a small part in helping students on their way to becoming successful professionals, that is the ultimate reward this job provides."

Associate Professor at Adelphi University's Department of Physics, Bentley earned his B.S. and M.S. in Electrical Engineering at the University of Missouri-Rolla (now Missouri University of Science and Technology). His PhD in Optics was earned at the University of Rochester.

He spent two years as Director of the Society of Physics Students (SPS) and Sigma Pi Sigma (the physics honor society), and has been a professor for nearly 19 years. In 2013, Bentley was nominated by his students and recognized by the Adelphi University faculty and administration with the Teaching Excellence Award for Tenured Professors. This is no small feat for a physics professor, as typically they teach some of the hardest material on campus. It was additionally amazing considering his reputation among the students as a demanding professor. But what is really amazing is his connection with the students. Students pile out of his office almost daily. He patiently works with all students who want help.

In co-curricular activities his teaching and leadership are outstanding. Adelphi University's Physics Club remains recognized as an Outstanding Physics Club by SPS for over fifteen years largely because of Bentley's work with the students. He teaches them to run events, how to be leaders, and how to find jobs. He is a behind-the-scenes guy who makes things happen and then steps away when the awards are given out.

Bentley's scholarship is also based in the teaching model, as he leads a student-focused, undergraduate research program. He has had an impressive list of students who have done research in his lab over the years. He keeps using every opportunity to enrich each student's life and is a successful mentor.

The David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching was established as the Excellence in Undergraduate Teaching Award in 1993. It was renamed and substantially endowed in 2010 by John Wiley and Sons. Named for David Halliday and Robert Resnick, the award recognizes outstanding achievement in teaching undergraduate physics.

Some Pain, Much Gain

Tuesday, July 12

2:30–3:50 p.m.
Hotel: Ambassador Ballroom

Homer L. Dodge Citation for Distinguished Service to AAPT

Tuesday, July 12 • 2:30–3:50 p.m. • Hotel: Ambassador Ballroom

Paula Heron

Paula Heron

Paula Heron, a Professor of Physics at the University of Washington, Seattle, WA is honored for exemplary service contributions to the mission of the American Association of Physics Teachers to promote the pedagogical skills and physics knowledge of the teachers at all levels, and to increase understanding of physics learning and of ways to improve teaching effectiveness, and to disseminate this knowledge to a broader community of physics educators. Regarding her selection to receive this citation, Heron said, "AAPT has played a vital role in my professional life so I am truly honored to receive this award, which has been given to so many physics educators who I admire and respect. It has been a pleasure to support AAPT and its mission, which has never been more important."

A member of AAPT since 1996, Heron has served on several committees including the Committee on Teacher Preparation, Committee on Research in Physics Education, and the Committee on Women in Physics as well as the Nominating and Programs committees. A senior member of the PER community who has contributed a great deal to the understanding of learning and teaching in physics, Heron is well known for her abundant service to the physics education community more broadly, and specifically to AAPT.

In 2014 she co-chaired the AAPT/APS Joint Task Force on Undergraduate Physics Programs, which was charged with addressing the question, "What skills and knowledge should the next generation of undergraduate physics degree holders possess to be well prepared for a diverse set of careers?" She brought a deep knowledge of AAPT and all of its many activities to the Task Force. The outcome of this work was the report Phys21: Preparing Physics Students for 21st Century Careers released in October 2016. Many talks about the task force's findings have been given at AAPT and APS meetings, and the report is beginning to have a significant influence on physics programs across the country.

Heron has also made important contributions to the AAPT publications *American Journal of Physics* (AJP) and *The Physics Teacher* (TPT). As a member of the Editorial Board of *TPT* she helped guide the journal to better serve its community and brought valuable perspectives from her service in various leadership and advisory roles on related APS journals (including Phys. Rev. PER) and her long engagement with various AAPT activities in teacher preparation. As a member of the search committee for the new Editor of AJP she leveraged her extensive contacts in the physics education community to help recruit Beth Parks. Many people contribute to AAPT's mission in physics education by writing and refereeing manuscripts for these two journals, but few have had as significant a leadership role in both of them.

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 2022 Fellows are:

Paula Heron University of Washington, Seattle, WA ***Geraldine Cochran,*** Rutgers University, Piscataway, NJ

Laura McCullough, University of Wisconsin-Stout, Menomonie, WI

Arlisa Richardson, Chandler Gilbert Community College, Gilbert, AZ

PLENARY I: Seeing Out of Both Eyes, by Ed Galindo

Dr. Galindo (Yaqui, American Indian) is a faculty member at the University of Idaho, Associate Director for Education and Diversity for the NASA Idaho Space Grant Consortium, Affiliate faculty member at Idaho State University (Biology Department) and Affiliate faculty member at Utah State University (Physics Department). Dr. Galindo has extensive education and research in working with Native American students. While serving as chairman of the science department on the Shoshone-Bannock Indian Reservation, he was twice elected as the National Indian Teacher of the Year, awarded by the National Indian School Board Association. Dr. Galindo describes himself as "round and brown", full of curiosity for life and learning. He finds humor in most things on this planet, including himself.

Ed is very proud to currently be serving as a board member with the Barry M Goldwater Scholarship and Excellence in Education Foundation. Most recently, Ed was honored to be inducted as a lifetime (Sequoyah Fellow) member of the American Indian Science and Engineering Society (AISES) for research and educational outreach in the American Indian communities. The Native American Research and Education Foundation was a host of an honoring dinner held at Las Vegas Nevada in April (2016). Dr. Douglas Duncan is an astronomer at the University of Colorado. From 2002-2018 he directed Fiske Planetarium, leading it to be the most advanced planetarium in the US. Duncan earned degrees at Caltech and the Univ. of California Santa Cruz. He was part of the project that first found sunspot cycles on other stars. Subsequently he joined the staff of the Hubble Space Telescope. In 1992 he accepted a joint appointment at the University of Chicago and the Adler Planetarium, beginning a trend of modernization of planetariums which has spread to New York, Denver, Los Angeles, and now Boulder Colorado. He has more than 50 refereed publications that have been cited over 7,000 times.

Ed Galindo

Monday, July 11

11 a.m. – 12 p.m.

Hotel:
Ambassador
Ballroom

PLENARY II: *Wendy Adams*

Wendy is a Research Associate Professor at the Colorado School of Mines with over 15 years of teaching from introductory physics to graduate-level science education research seminars. Her research focuses on formative assessment and curriculum design. Wendy developed the widely used CLASS, which measures students' perceptions of physics and how to learn physics. She has also completed extensive work on problem-solving evaluation and developed the interface design guidelines for the PhET Interactive Simulations. Wendy recently developed the PTaP (Perceptions of Teaching as a Profession) instrument. She also designed and developed several curricula, including the (Explore Sound project – K14) materials for acoustics.

Wendy Adams

Tuesday, July 12

11 a.m.–12 p.m.

Hotel:
Ambassador
Ballroom

Douglas Duncan

Wednesday, July 13

11 a.m. – 12 p.m.

Hotel: Ambassador Ballroom

PLENARY III: Run a 2023 and 2024 Eclipse Event at Your School, for Fun, Education, and Profit!, by Douglas Duncan

Duncan is well known as a popularizer of astronomy. From 1997-2002 he did science commentary on the Chicago Public Radio station WBEZ and he is now heard on the Colorado Public Radio program "Colorado Matters." He has appeared on television programs such as the History Channel and BBC Horizon. In 2011 he received the prestigious Richard Emmons award presented to the "Outstanding University Astronomy Teacher in the US." He has a grant from NASA to produce and nationally distribute 360 degree ("Full-dome") planetarium features highlighting NASA's varied missions.

Duncan has served as National Education Coordinator for the American Astronomical Society, representing the 7000 professional astronomers in the US and leading efforts for better teaching and public communication for astronomers throughout the country. His work has been funded by the National Science Foundation, NASA, the National Oceanographic and Atmospheric Administration, the Smithsonian, and National Geographic. His most recent work is on the correlation between student texting and grades. It shows that 70% of university students text during class, and their grades are 4-5% lower!

Duncan leads educational trips throughout the world to watch total eclipses of the sun and to see the northern lights. In 2017, for the best US Total Eclipse in 40 years, helped arrange for 7000 libraries to have 2.1 million pairs of safe eclipse watching glasses. In 1991 Duncan travelled to the North Pole and was elected to The Explorer's Club of New York City.

His home page is at http://casa.colorado.edu/~dduncan and his email is dduncan@colorado.edu

Hashim A. Yamani Membership Grants

Each year, AAPT awards several two-year Hashim A. Yamani AAPT Memberships, which are regular electronic memberships and include electronic only access to copies of the *American Journal of Physics*, *The Physics Teacher*, and *Physics Today.* These grants are supported by the Hashim A. Yamani Fund, which was endowed in 2011 by generous contributions from several colleagues and mentees of Dr. Hashim A. Yamani, a prominent and well respected physics educator, researcher, and public servant in Saudi Arabia. An individual eligible for a Yamani Membership must be either an undergraduate senior who is planning a career teaching physics in his or her native country, or a graduate student who is in his or her last two years before receiving his or her final post-baccalaureate degree and who is planning a career teaching physics in his or her native country, or an early-career professional in his or her first five years of physics teaching in his or her native country. Citizens of any country in the world are eligible for support but citizens of developing countries in such areas as the Middle East, Africa, and Southeast Asia will have priority over citizens of developed countries in such areas as North America and Western Europe.

Submit an Application @ *http://www.aapt.org/Programs/grants/Yamani.cfm*

EXHIBITORS AT SUMMER MEETING

Exhibit Hall: Convention Center Exhibit Hall C

Hours: Sunday: 7–9 p.m. Opening Reception
Monday: 10 a.m.–5 p.m.
Tuesday: 10 a.m.–4 p.m.

4th Law Labs

AAPT Membership

AAPT Publications

American Physical Society

Arbor Scientific

Bedford, Freeman, & Worth Publishers

Carolina Distance Learning

Digitalis Education Solutions Inc.

Expert TA

Grand Valley State University with the Michigan Section

Macmillan Learning

PASCO scientific

Pivot Interactive

Quantum Experience Inc.

Society of Physics Students

Supersaturated Environments

Thor Labs

Vernier Software and Technology

W09B Online Data and Image Analysis Using JS9

July 9, 2022 8 a.m.–Noon DEV 109D GVSU-Grand Rapids Campus

Pamela Perry

Web-based JS9 has the ability to display any FITS file, which is a good starting point for understanding a myriad of observations across the gamut of observed energies, from infra-red to gamma rays. FITS files, unlike standard JPEGs (which look the same) contain underlying data of position, energy, and arrival time of each photon in the image. Thus, students can explore energy spectra, light curves, periodic phenomena and a wealth of other analysis tasks that are fun and easy to use. This workshop will give participants the opportunity to do activities on element formation in supernova, supernova expansion, identifying white dwarfs and pulsars using light curves and rotation rates, making three color composites, and star formation in colliding galaxies as well as research opportunities using js9.

W09C Physics Inquiry Using the Sensors in Phones

July 9, 2022 8 a.m.–Noon DEV 119E GVSU-Grand Rapids Campus

Michelle Milne

Smartphones come equipped with high quality sensors which students can use to engage in science and engineering practices as they learn core physics concepts. Participants in this workshop will work through several example introductory lab experiments themselves taking data on their phone and will learn about the wide variety of sensors available to create introductory physics experiments for their own students. Participants should bring their own smartphone or tablet to this workshop.

W09D Jupyter Notebook (CoLab) in the Physics Classroom

July 9, 2022 8 a.m.–Noon DEV 107D GVSU-Grand Rapids Campus

Paul Beeken

Introduction to using Jupyter Notebook (Google CoLab, an online version) in the introductory physics classroom as an an instructional resource for problem solving, modelling, and lab write-ups. The target audience are instructors in the high school and community college arena looking to use this open source resource for helping students explore physical models with computation. Using Google's CoLab (because of its zero setup and ready availability) we will cover the basics of the Jupyter notebook framework. The attendee will leanr the basics of 'markdown' and LaTeX, the authoring tool for communicating through prose and mathematics as well as the basics of the python language. This is not intended as an exploration of programming. By using readily available libraries (most notably, numpy) the 'coding' skills needed are little more advanced that knowing how to use a modern graphical calculator. Participating instructors should be able to walk away with active worksheets and/or lab materials that they can use as a launching point for their own classes. A library of worksheets and lab starting points will also be made available as well.

W09F Engaging Students with New Data-driven Astronomy Investigations

July 9, 2022 8 a.m.–Noon DEV 117E GVSU-Grand Rapids Campus

Ed Prather

Looking for a way to actively engage your students in learning core ideas in astronomy? The education team at Rubin Observatory has developed a new suite of classroom-tested online investigations that incorporate a unique combination of data-representations, simulations and analysis tasks to guide learners' exploration of contemporary astronomy data. Each standalone investigation comes with a teacher guide, formative/summative assessments (think-pair-share, pre/post, and open-ended), and NGSS support (phenomenon, rubrics, etc.). The investigations are designed for novice learners from advanced middle school through the introductory college level and cover topics ranging from Hubble's Law to Hazardous Asteroids. This workshop will take a deep dive into an investigation on small bodies of the Solar System, that can enhance students' data analysis and evidence-based reasoning abilities, and their understanding of Kepler's Laws, Newton's Laws, gravity, and the formation of the Solar System. Participants will have time to explore these new investigations and discuss ideas for successfully integrating them into their classroom.

W09G Science Communications

July 9, 2022 8 a.m.–Noon Hotel: Nelson

Rebecca Thompson

Communicating the excitement of science is a specialized skill. This course is geared towards scientists who want to learn how to best engage an audience, targeting effective approaches to presenting scientific discovery and fundamentals.

W09H Incorporating Mindfulness Practices into Physics Teaching

July 9, 2022, 8–12 Hotel: Thornapple

Karen Gipson, Grand Valley State University

Mindfulness is the act of paying attention to the present moment with an attitude of non-judgmental curiosity. There is a growing body of evidence* that the practice of mindfulness has significant positive impacts on both physical and mental health - for example, ameliorating stress and improving concentration. Since many students, perhaps especially those in introductory physics courses, report feeling stressed and also since they need to be able to concentrate to do physics (often in a different way than in other disciplines), offering them the tool of mindfulness makes perfect sense. This workshop will begin with a brief overview of the science of mindfulness and the facilitator's successes with incorporating mindfulness techniques in various types of college physics courses. The bulk of the workshop will be devoted to experiential exercises and group discussions. Attendees will learn and practice simple mindfulness techniques and will be provided resources designed to incorporate mindfulness activities into their courses. In addition to teaching physics for over two decades, the facilitator for this workshop is a member of the Association for Contemplative Mind in Higher Education and a trained facilitator/instructor in various styles of mindfulness. *See, for

example, (a) Davis and Hayes ("What Are the Benefits of Mindfulness? A Practice Review of Psychotherapy-Related Research", (2011). Psychotherapy, Vol. 48 (2): 198-208) for a review of psychological benefits; (b) Grossman, Niemann, Schmidt & Walach. ("Mindfulness-based stress reduction and health benefits: A meta-analysis." J. of Psychosomatic Research. 2004; 57: 35-43) for a review of health benefits; and (c) https://korumindfulness.org/evidence/ for a more recent study of one particular method of teaching mindfulness"

W092A Surface Mount Electronics How-To (Design with KiCad)

July 9, 2022, 1–5 p.m. PAD 259 GVSU-Allendale Campus

Eric Ayars

This workshop will give participants guided opportunity to design their own circuitboard using the open-source KiCad package. It will cover how to make a schematic, how to turn the schematic into a board layout, and creation of Gerber files to turn the design into a physical device. It is intended to be taken with the "Surface Mount How-To (Techniques for building)" workshop, but can be taken by itself if desired.

W09E PIRA Lecture Demonstrations I & II Condensed

July 9, 2022 1–5 p.m. PAD 106 GVSU-Allendale Campus

Dale, Stille, University of Iowa; Sam Sampere, Syracuse University

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.

W092C Conducting and Publishing Double Star Research

July 9, 2022, 1–5 p.m. DEV 223E GVSU-Grand Rapids Campus

Rachel Freed

In this workshop participants will go through the process of selecting a double star system to study, learn how to access Las Cumbres Observatory (LCO) remote telescopes, and be given an introduction to the basic research process for double star astrometry. The tools employed include a GAIA double star selection tool, remote access to LCO telescopes, and AstroImageJ for data analysis. Participants will receive access to the Canvas course with all course materials prepared for the seminar. We will also review the process whereby student and teacher teams learn how to write up their results for publication in the Journal of Double Star Observations (jdso.org). Participants are encouraged to download AstroImageJ in advance of the workshop. https://www.astro.louisville.edu/software/astroimagej/

W092D Creating Curricular Materials to Accompany Physics Simulations

July 9, 2022, 1–5 p.m. DEV 225E GVSU-Grand Rapids Campus

Andrew Duffy

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.

W092E Introduction to Data Science with RStudio

July 9, 2022, 1–5 p.m. DEV 109D GVSU-Grand Rapids Campus

Jayson Nissen

This workshop covers statistical tests for comparing two groups and a process for learning new statistical methods by applying these methods to common tasks in physics education research. The application, interpretation and limitations of common inferential tests will be emphasized by focusing on developing a conceptual understanding of variance in data, visualizations that account for variance, and the relationships between variance, effect sizes, and p-values. Participants will work in small groups with facilitators and participate in larger group discussions. They will compare scores on concept inventories and responses to a multiple-choice question using parametric tests for interval and ratio scale data and nonparametric tests for ordinal and nominal data. To facilitate these conversations, we will provide a working file in RStudio; however, participants do not need any prior experience with statistics or with RStudio. We invite more advanced RStudio users and quantitative researchers to participate and to support other participants. By focusing on the process for learning new statistical methods, participants will leave with skills and resources to conduct, evaluate, and report their own analyses.

W092F The Half-Flipped Classroom: Just In Time Teaching

July 9, 2022, 1–5 p.m. Hotel Nelson

Andrew Gavrin

This workshop will introduce participants to the Just-in-Time Teaching (JiTT) strategy. A method that has been shown to improve students' results in a wide range of courses in physics and other subjects. JiTT combines well with other teaching methods, and can be viewed as a "partially flipped" classroom: students are encouraged prepare for class (but not necessarily with video) and class time is used for interactive activities (but only partially). It is flexible, and can easily be adapted to many courses, class sizes, and institutions.

JiTT incentivizes students to prepare for class, and uses the results of their preparations to improve what happens during class time. Students complete brief

"warmup" assignments before each class. These assignments are not typical homework, rather, they are conceptual questions that students complete by reading the textbook or other assigned materials. The warmups are due a few hours to one day before class, allowing the instructor to read the students' answers. As a result:

- Students are much more likely to prepare for class
- Students' reading of the text is more focused on important issues
- Instructors see in advance what ideas have caused students the most difficulty and adjust plans "just in time."
- Instructors can use excerpts from the students' answers in class, making the class more focused on students' learning.

I will present the reasoning behind the JiTT method, details of its use, and tips for how best to implement it in physics classes. Participants will discuss how it fits with their needs, and practice writing JiTT questions.

W092G WebPython for Beginners: Integrating Coding in the Classroom

July 9, 2022, 1–5 p.m. DEV 119E GVSU-Grand Rapids Campus

Tom O'Kuma

Over the last few years, there has been a push to integrate computational modeling in the introductory physics curriculum. This is a workshop for novice coding learners, where participants will learn basic steps in WebVPython (also known as GlowScript) and practice with codes that demonstrate physics principles ranging from conceptual to calculus-based level. Participants will practice with activities that could be directly integrated into the classroom, starting with simple working codes where physical modelling will be incrementally added through guided steps. Further examples of classroom utilization of coding will be provided, and a discussion on the frequency of integration of computational methods in the classroom will be promoted. Participants are asked to bring their own laptops and to create an account in webvpython.org before arrival. This workshop is proudly supported by the Organization of Physics in Two Year Colleges, OPTYCs.

WORKSHOPS AT SUMMER MEETING — SUNDAY, JULY 10

W10A Teaching Waves with PEER Physics Open Source Resources for General Physics

July 10, 2022, 8 a.m.–Noon Hotel: Thornapple

Emily Quinty

In this interactive workshop, participants will engage with the PEER Physics Waves unit. PEER Physics offers a suite of curricular resources, professional learning, and teacher networks, specifically geared toward the high school general physics classroom and enacting NGSS ideals. We are releasing open source (FREE!) materials for teaching waves, aligned with the NGSS. Dive into these new resources while considering ways of supporting students with the process of building claims from evidence. Participants will engage with student work to ultimately characterize the classroom conditions necessary for students to build claims and develop models from evidence. Participants will discuss their roles in helping students integrate physics content and scientific practices as they develop models, explanations, and principles that explain the physical world.

W10B Coding Integration and Data Science Integration in High School Physics and Physical Science

July 10, 2022, 8 a.m.–Noon DEV 203E GVSU-Grand Rapids Campus

Chris Orban

Ever wondered how to integrate a little bit of coding or data science into a high school physics or physical science class without overwhelming your students or taking up lots of class time? This hands-on workshop will provide an overview of simple, conceptually-motivated "STEMcoding" exercises where students construct PhET-like games like asteroids and angry birds using an in-browser editor that works great on chromebooks or whatever devices you have. We will also provide a tutorial of the STEMcoding Object Tracker which is a browser-based program that can track the motion of brightly colored objects 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). The STEMcoding project is led by Prof. Chris Orban from Ohio State Physics and Prof. Richelle Teeling-Smith in the physics department at the University of Mt. Union.

W10D Developing the Next Generation of Physics Assessments

July 10, 2022, 8 a.m.–Noon Hotel: Pearl

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.

W10E Get the Facts Out

July 10, 2022, 8 a.m.–Noon DEV 205E GVSU-Grand Rapids Campus

Drew Isola

In this workshop we will share strategies and resources for recruiting students into physics, chemistry, math and general science teaching careers. The strategies include recommendations for sharing facts about teaching, how to talk to students, listing of venues for reaching students, updated recommendations and resources for sharing the facts virtually. The online resources provided include student presentations, posters, brochures, program flyer templates and presentations for faculty and staff who advise students. All materials are professional quality, research-based and have been extensively user-tested. These materials have been developed as part of Get the Facts Out, an NSF funded project for changing the conversation around STEM teaching recruitment. The project is a partnership between the American Physical Society, American Chemical Society, the Association of Mathematics Teacher Educators, and AAPT led by the Colorado School of Mines. This workshop is fully funded by NSF #1821710 & 1821462. Participants who complete this workshop can be reimbursed for their workshop registration fee.

W10F PICUP: Integrating Computation into Upper-level Physics Coursees

July 10, 2022, 8 a.m.–Noon DEV 117E GVSU-Grand Rapids Campus

Todd Zimmerman

In this workshop, we will show you ways in which computation can be integrated into your upper-level physics courses. The PICUP partnership has developed a variety of computational activities for teaching 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.

W10G Smartphones in the Astronomy Classroom

July 10, 2022, 8 a.m.–Noon DEV 119E GVSU-Grand Rapids Campus

Kevin Lee

This workshop will describe and illustrate early efforts to utilize student smartphones in and out of 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 HTML5 ranking task editor and examples created in it. The necessary steps to create a task will be outlined and then participants will be asked to create their own ranking task online and save it 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 eclipse simulations, useful for the upcoming widely observable solar eclipses in 2023 and 2024. 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 task creation.

W102A Green and Renewable Energies

July 10, 2022, 1–5 p.m. DEV 119E GVSU-Grand Rapids Campus

Joe Kozminski

Labs and activities dealing with green and renewable energy, energy and the environment, and sustainability are great for getting students interested in and excited about science. Putting physics in this context can make it more real and relevant for the students. This workshop will engage participants in several green-themed activities that could be used for classroom laboratories or for outreach. These labs andactivities can be implemented at relatively low cost.

W102B Improving the Pedagogical Content Knowledge of Teaching Assistants and Instructors

July 10, 2022, 1–5 p.m. Hotel: Haldane

Alexandru Maries

Being aware of common student alternate conceptions in physics is beneficial when designing instruction to help students develop a coherent knowledge structure. It is thus not surprising that knowledge of common student difficulties is one aspect of what Shulman coined "pedagogical content knowledge", or in other words, knowledge about how to teach a subject that is different from the content knowledge itself. This workshop will first explore the literature on the extent to which TAs (undergraduate and graduate students teaching labs and recitations) and instructors are aware of various introductory student alternate conceptions. Participants will identify common alternate conceptions of students in certain question and discuss potential uses in a professional development class. In addition, participants will discuss productive approaches to help both TAs and instructors learn about these alternate conceptions and integrate this knowledge into their pedagogical design.

W102D Assessing Mathematical Reasoning Development in Physics Using the Physics Inventory of Quantitative Literacy (PIQL)

July 10, 2022, 1–5 p.m. DEV 225E GVSU-Grand Rapids Campus

Trevor Smith

Productive mathematical sensemaking is a habit of mind common to students who are successful in learning introductory physics (Sherin 2001). It underpins introductory physics courses and is reflected in the Science Practices of both the NGSS, and the AP Physics tests. Currently, there are very few validated tools for instructors interested in developing mathematical sensemaking in their instruction. This workshop introduces the Physics Inventory of Quantitative Literacy (PIQL), a new research-validated assessment tool for assessing mathematical sensemaking that is foundational to introductory physics (White Brahmia et al. 2021.) The PIQL is designed for instructors to assess the effectiveness of their efforts to help their students develop the quantitative reasoning habits of mind foundational to introductory physics courses - as well as the NGSS and AP Physics curriculum framework. Participants will learn about expert frameworks that help characterize mathematical reasoning in introductory physics. They will engage in collaborative activities to clarify the kind of reasoning that is being assessed on the PIQL, and why it is important. We will discuss methods for scoring PIQL responses and how to interpret the results. Participants will then form working groups and brainstorm about the physics contexts in which this mathematical reasoning is particularly important. The workshop will finish with a whole-group discussion of instructional activities currently available that show promise for improving the kind of reasoning measured by the PIQL.

W102E Building Apparatus @ Home

July 10, 2022, 1–5 p.m. Hotel: Nelson

Stephen Irons

Workshop demonstrating how to make use of household materials to construct useful tools for performing physics experiments. Emphasis will be on common, inexpensive materials. Workshop will be divided into three parts, a presentation, a brainstorming session, and a construction phase, during which participants will build and test their own pieces of apparatus made from commonly available materials. All materials will be provided.

W102H Intermediate and Advanced Labs

July 10, 2022, 1–5 p.m. PAD 205 GVSU-Allendale Campus

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, equiPM MONDAYent lists, and construction or purchase information.

W102I Group Worthy Tasks

July 10, 2022, 1–5 p.m. DEV 213E GVSU-Grand Rapids Campus

Kelly O'Shea

Students often learn and work in groups, and scientists also work in teams. How can we make sure that the tasks we give students are really group-worthy? In Designing Groupwork: Strategies for the Heterogeneous Classroom, a group-worthy task is defined as one that is open-ended, provides multiple entry points and multiple ways to demonstrate knowledge, and requires positive interdependence from students. Because group-worthy tasks emphasize the value of multiple abilities and a range of approaches to a problem, they provide the opportunity for all students to engage deeply and meaningfully with the content. These types of tasks also often meet many of the NGSS Science and Engineering Practices. In this workshop, we will discuss characteristics of group-worthy tasks and share tasks that the presenters have used. Participants will also have the opportunity to work on adapting and applying these ideas for their own classrooms. Although we hope that this workshop will be interesting to a wide audience, our target audience is high school teachers.

W102K Examining the Relationships Among Intuition, Reasoning, and Conceptual Understanding in Physics

July 10, 2022, 1–5 p.m. DEV 223E GVSU-Grand Rapids Campus

Andrew Boudreaux

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

W092A Surface Mount Electronics How-To (Techniques for Building)

July 10, 2022, 1–5 p.m. PAD 259 GVSU-Allendale Campus

Eric Ayars

This workshop will give participants a guided opportunity to build a circuit board using modern surface-mount components. It will cover a variety of techniques including hand-soldering, hot-air reflow, solder paste and stencils, and reflow ovens. It is intended to be taken with the "Surface Mount How-To (Design with KiCad)" workshop, but can be taken by itself if desired.

STEP UP

PHYSICS TOGETHER

STEP UP is a national community of physics teachers, researchers, and professional societies. We design high school physics lessons to empower teachers, create cultural change, and inspire young women to pursue physics in college.

If half of the high school physics teachers encourage just one more female student to pursue physics as a major, a historic shift will be initiated — female students will make up 50% of incoming physics majors.

Are you a high school physics teacher, or do you know a high school physics teacher?

Join the STEP UP community to download the curriculum and help recruit teachers to the movement.

STEPUPphysics.org

SPS Undergraduate Posters

Location: CC: Exhibit Hall C **Sponsor:** SPS/AAPT
Time: 7–9 p.m. **Date:** Sunday, July 10 **Presider:** TBA

SPS01: Modeling the Omicron Wave of COVID-19 with the SIR Model

Poster – Presenting Author: Thaddeus Smith, Fisk University

Additional Author | Peter Hugo Nelson, Fisk University

The susceptible-infectious-recovered (SIR) model is used to gain insights into the spread of COVID-19 in the United States during the omicron wave from December 2021 to April 2022. During that time, new COVID-19 infections are believed to have been caused primarily by the omicron (B.1.1.529) variant of the SARS-CoV-2 virus. In our model we assume that the reported infection rate data were caused solely by the omicron variant, independent of prior infection by other variants of COVID-19 and vaccinations. We fitted the infection rate data to the SIR model using three adjustable parameters: model population size, infection rate constant, and initial number infectious. Those parameters determine the height, width, and timing of the peak in the omicron wave, respectively. The resulting model successfully explains the omicron wave in the US, thus providing support for our assumptions and indicating that there is no significant difference between selected States of the Union.

*Supported by NSF Grant No. 1817282.

SPS02: Creating Motion and Forces Content in an Exploratory Computer Game

Poster – Presenting Author: Fiona Warner, Bowling Green State University

Additional Author | Eric S Mandell, Bowling Green State University

This project focuses on the creation of physics educational content and its use in a digital Story-Based Learning Role-Playing Game (RPG). RPGs provide a more engaging and relaxed environment for student learning by blending course content with story and exploration. This RPG is being built with RPG Maker MZ and we are utilizing Twine for dialogue development. Previous versions of the game with vectors and math review were shared with students, and surveys showed that student engagement was positive. Here, we further developed this version to include motion and forces content, and plan to share it with introductory physics classes, ideally in fall 2022.

SPS03: Personal Neutron Dosimeter Measuring Cosmic Rays in Stratospheric Ballooning Missions.

Poster – Presenting Author: Zoe Sternberg, St. Catherine University

Presenting Author | Kaitlyn Blair, St. Catherine University

Additional Author | Anisa Tapper, St. Catherine University

Presenting Author | Hope Holte, St. Catherine University

Helium-filled High Altitude Balloons (HABs) have been used by St. Catherine University all women's research team to investigate the near-space environment. Due to low pressure, the balloons expand until they burst at approximately 32 km. Cosmic ray showers colliding with atmospheric particles are significant in the region where these HABs are flown. One of the constituents of the collision process is neutrons. A personal neutron dosimeter (PND) can be used to quantify neutrons through the appearance of bubbles as a result of neutron reactions with a liquid substrate. Over the years, flights have been flown consisting of a PND, heater circuit, Geiger – Mueller tubes, GPS, and a GoPro camera. Data analysis shows a correlation between the altitude of the neutrons in comparison to other shower-generated particles. The particle peak occurs between 15-25 km – correlating to the charged particle maximum known as the Regener-Pfotzer maximum.

SPS04: Defining Adaptive Free Choice in a Conscious System

Poster – Presenting Author: Hannah ChaPM MONDAYan, Saint Anselm College

Our goal is to create a mathematical function to represent what free choice is, using primarily philosophy as well as statistical and quantum mechanics. Other researchers are working on similar projects pertaining to agency and consciousness, of which we have employed ideas from theoretical physicist Carlo Rovelli (Rovelli 2020) and a group at the Wisconsin Institute (Oizumi et al. 2014). We assume the existence of free will, because regardless of whether or not we have it, we act in accordance with it. A more rigorous definition of freedom of choice must be a prerequisite to any deeper understanding of free will. The project is within the scope of theoretical physics, requiring precision about how conscious phenomenon is described within our model. Carlo Rovelli's Agency in Physics focuses on connecting statistical mechanics with modes of agency (2020), while Ian Durham's model has been creating a function of adaptive free choice (2021).

Session AA: 21st Century Physics in the Classroom I

Location: CC: Grand Gallery A **Sponsor:** Committee on Physics in High Schools
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** TBA

AA01 (8:00 to 8:30 AM MONDAY) Planning Effective Professional Development

Invited – Presenting Author: Deborah Roudebush, QuarkNet

QuarkNet is a project funded by NSF, ATLAS, CMS and Fermilab with additional support from participating universities. My role in the project is to oversee the Data Activities Portfolio (DAP), a compendium of activities to help teachers incorporate 21st Century physics into their curriculum. This talk will explain the DAP structure that follows guidelines for Effective Teacher Professional Development as described by Linda Darling-Hammond, Maria E. Hyler, and Madelyn Gardner, with assistance from Danny Espinoza. We will provide data about the efficacy of our activities in the classroom.

AA02 (8:30 to 9:00 AM MONDAY) Renewable Energy and Climate Change in the Classroom and Lab

Invited – Presenting Author: Joseph Kozminski, Lewis University

Climate change is one of the most important challenges facing our world, and it will impact us all. Incorporating climate change and renewable energy topics into physics classes and labs at all levels is a way to not only demonstrate physics concepts through relevant applications but also provide awareness of some of the issues around climate change and possible mitigation strategies. Some topics that will be covered include energy flows and energy conversion, power generation using solar cells and wind turbines, and data analysis using climate data.

Session AB: Apparatus @ Home

Location: CC: Grand Gallery B **Sponsor:** Committee on Apparatus
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** Stephen Irons

AB01 (8:00 to 8:10 AM MONDAY) Take-home Experiment: Student-led Exploration of Coupled Harmonic Oscillators

Contributed – Presenting Author: Ilya Beskin, University of Texas at Austin

Additional Author | Daniel J Heinzen, University of Texas at Austin

With the transition to remote learning, many lab-based curricula had to be quickly amended. Here, I present a build-it-yourself experiment that can be used by students with a wide range of mathematical backgrounds to explore principles of mechanics and experimental design. This coupled harmonic oscillator experiment, initially developed for a sophomore level waves and optics lab at UT Austin, is built with readily available materials and doesn't suffer from parametric oscillations: a common difficulty in such experiments. In an introductory physics class, this experiment can be used as a platform to discuss transfer of energy and momentum in a system that challenges students' intuition. Freedom in the setup's construction leads to student-led investigations of experimental error mitigation. Students familiar with trigonometry can explore the small angle approximation. Finally, students familiar with linear algebra can study decomposition of waves into sinusoidal (eigen-function) components, and an introduction to Fourier transforms.

AB02 (8:10 to 8:20 AM MONDAY) Lab Kits for 'At-Home' Experiments in Physics for Life Sciences

Contributed – Presenting Author: Michael Massa, University of Guelph

Additional Author | James Ball, University of Guelph

Additional Author | Jason Thomas, University of Guelph

For the second year of the pandemic, we developed new labs for our life-science stream intro physics courses. Despite the return to on-campus learning, our students engaged in unscheduled, remote experiments. The goal of our labs was to connect life science topics (fluids, optics, spectroscopy) to an everyday context through hands-on experiments. We created 'at-home' lab kits for students, combining common items (rulers, string, battery) reinforced with standardized items for consistency (e.g. known masses) and specialized materials (capillaries, LEDs, diffraction grating). We employed smart phone apps for measurement, embedded Geogebra for data analysis, and complemented activities with the video- and simulation-elements from virtual labs of the previous year. Some of highlights of our experience over the year include: a citizen-science lab, insights into the workflow of students, and their preference regarding 'scheduled & on-campus' vs 'asynchronous & remote'.

AB03 (8:20 to 8:30 AM) Using Circuit Kits and LEDs to Teach Optics at Home

Contributed – Presenting Author: Melissa Vigil, Marquette University

During the Spring and Summer sessions of 2020 and 2021, our students used the circuit kits we sent them to create light sources for use in the optics portion of the course. Various single-colored LEDs and an RGB LED were used with the Fresnel-lens book mark and diffraction grating slides included in their kit to explore ray optics, image formation, color mixing, and interference effects. Christmas lights, Fresnel book marks, magnifying glasses, and reading glasses were could be used in the explorations by those without access to the kits. The use of multi-colored light sources increased the quality of student discussion of the concepts involved.

Session AC: Computation and Modeling to Non-science Majors I

Location: CC: Grand Gallery C **Sponsor:** Committee on Educational Technologies
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** Jay Wang

AC01 (8:00 to 8:30 AM MONDAY) Teaching Machine Learning to Non-Scientists

Invited – Presenting Author: Donald Smith, Guilford College

Machine Learning (ML) is becoming ubiquitous in the realms of science, business, law enforcement, and even the arts. I have developed a three-week general education course on machine learning for non-scientists. Each day in the first half of the course, students engage with demonstrations and tutorials. They learn how to implement simple examples of text and image classification as well as generative algorithms and adversarial networks. In the second half of the course, the students carry out a project of their own design. I do not assume students have previous experience with programming, calculus, or ML algorithms. They learn by experimenting with existing code to achieve goals of increasing complexity. I will report on the successes and challenges of this course and share what I have learned about how students can effectively grapple with the opportunities and dangers that ML represents.

AC02 (8:30 to 9:00 AM MONDAY) Using Computation to Make General Education Courses Contemporary and Compelling

Invited – Presenting Author: Aaron Titus, High Point University

We integrate computation into all courses for physics majors, starting with the introductory physics course where we use the textbook Matter & Interactions and teach students to write code in VPython to model physical systems. However, we also integrate computation into general education courses for non-science majors. In particular, we teach a course Physics for Video Games wherein students learn conceptual physics and apply it in creating video games with realistic physics. We also teach a course in computational modeling in our Honors program wherein students write Monte Carlo simulations and solve ODEs numerically. In both cases, we learned the importance of eliminating software installation, solving relevant and interesting problems, and emphasizing projects. All curricular material is available for you to adapt and use.

Session AD: Diversity, Equity, and Inclusion in K-12

Location: CC: Grand Gallery E **Sponsor:** Committee on Diversity in Physics
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** Alexis Knaub

AD01 (8:00 to 8:10 AM MONDAY) Critical Investigations of Physics Identity at HSIs*

Contributed – Presenting Author: Xandria Quichocho, Texas State University

Additional Author | Eleanor W. Close, Texas State University

Investigations on physics identity development are essential to student retention in physics degree programs. However, identity studies in physics education research have typically been conducted at Predominately White Institutions, and many do not investigate how physics identity is affected by the unique intersections of gender, sexuality, and race/ethnicity. In our research we invite multiply-marginalized physics students—those who live in these intersections of minoritized race/ethnicity, gender, and sexual orientation—to participate in semi-structured interviews about their physics experiences at Hispanic-Serving Institutions. The interviews center on how participants' physics identities interact with their social identities, and our analysis uses the Critical Physics Identity framework and Communities of Practice theory to fully understand the lived experiences of our participants. In this talk we will discuss the ways participants describe what it means to be a physicist, and how ideational and relational resources support or inhibit the development of their intersectional physics identity.

*This work has been supported in part by NSF grants DUE-1557405, DUE-1928596

AD02 (8:10 to 8:20 AM MONDAY) Exploring Identity Formation of Ethnic and Gender Minorities in Physics

Contributed – Presenting Author: Naomi Satoh, Illinois State University

Additional Author | James DiCaro, Illinois State University

Additional Author | Raymond Zich, Illinois State University

Physics is a space historically dominated by cis white men. Ethnic and gender minorities are often assigned general roles that they are expected to inhabit, drawn from preconceived notions of gender norms and ethnic stereotypes. It can become difficult for these groups to move through the field based on limitations of power structures and dynamics. We aim to explore undergraduate student perspectives and attitudes toward identity development and community formation within physics. Drawing ideas from personal experiences as well as less-explored topics, we will discuss possible ways to explore how students structure identities in physics and potential improvements to the physics classroom that can support inclusivity. This project focuses on student attitudes and perspectives at the undergraduate level. Our goal is to identify sources of bias among academia to create more inclusive and welcoming spaces for students learning physics.

AD03 (8:20 to 8:30 AM MONDAY) Equity in Introductory Physics Through Invitational Phrasing in Question Solicitation

Contributed – Presenting Author: Brokk Toggerson, University of Massachusetts Amherst

Additional Author | David Frykenberg, University of Massachusetts Amherst

Instructors often solicit student questions during class periods. Educational workshops often suggest that the script of question solicitation impacts the frequency of questions returned by students. However, no literature exists to support this claim. This study observed the effect of a new solicitation script an instructor integrated into his introductory physics lectures to improve question participation from his students. While the new solicitation script did not change the total number of questions asked by students, the number of questions asked by women, a group traditionally underrepresented in physics, increased significantly.

AD04 (8:30 to 8:40 AM MONDAY) A Critical Reframing of STEM Students' Support and Mentorship Channels

Contributed – Presenting Author: Brian Zamarripa Roman, University of Utah

Additional Author | Miguel Rodriguez, University of Utah

Additional Author | Ramón S Barthelemy, University of Utah

People of color remain underrepresented in science, technology, engineering, and mathematics, partly due to the historical marginalization of perspectives and values of people of color in academia. To counteract this marginalization and underrepresentation, it is crucial to reexamine academic support systems and expand them with explicit consideration for the values and experiences of students of color. This qualitative study examines helpful and mentor relationships identified by 23 students of color, including 17 international students, enrolled in STEM programs at mountain-west universities. The person-first approach guiding this study details features of relationships with individuals including research advisors and colleagues, as well as family members, religious and athletic leaders, and colleagues in industry. Findings confirm the need for a wide mentorship network to address academic and social concerns specific to participants' identities and should compel academic institutions to invest and foster relationships with nonacademic communities and various academic mentors to support students.

AD05 (8:40 to 8:50 AM MONDAY) ULAB: An Accessible, Peer-Led Framework for Facilitating Undergraduate Research Experiences*

Contributed – Presenting Author: Yi Zhu, UC Berkeley

Additional Author | Anmol Desai, UC Berkeley

Additional Author | Ravjit Kaur, UC Berkeley

Undergraduate research is a critical component of students' training in physics. How do we ensure these experiences are accessible to a diverse population of students? We present a unique case study of The Undergraduate Lab at Berkeley (ULAB), an undergraduate-run, research training course geared towards underrepresented and under-supported students at UC Berkeley. Student instructors teach vital research skills via a flexible curriculum suitable for students from diverse backgrounds. Beyond traditional instruction, ULAB mentees are paired with undergraduate mentors and together gain hands-on experience by designing and conducting a year-long research project with funding. We further present a pilot survey (n=47) exploring ULAB's effectiveness in building students' confidence in research skills and fostering sense of belonging to Berkeley's research community. Using qualitative and quantitative techniques developed in coordination with the Berkeley Undergraduate Research Evaluation Tools (BURET) group, we report observations on how ULAB may support diversity, equity, and inclusion.

*The authors would like to acknowledge support from the The Berkeley Discovery Initiative.

Session AE: Early Career Topical Discussion

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Research in Physics Education
Time: 8–9 a.m. **Date:** Monday July 11 **Presider:** Rachel Henderson

Postdocs, new faculty, and other junior Physics Education Research (PER) members are invited to this topical discussion to meet and discuss common issues. As this stage in a career can be a period of significant transition, we are hoping to provide a space to facilitate community building, resources, and professional development for those starting a career in PER. The session format will be an open discussion about identifying what are the needs of early career members in the community, how can we plan strategies to address those needs, and how to build the support structures for that community. We will ask participants to discuss these topics in small groups first, then share those ideas with the room.

Session AF: PER: Curriculum and Instruction I

Location: CC: Grand Gallery Overlook E/F **Sponsor:** Committee on Research in Physics Education
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** TBA

AF01 (8:00 to 8:10 AM MONDAY) Revitalizing the Laboratory Curriculum at a Research-Intensive Institution

Contributed – Presenting Author: Karen Cummings, University of Waterloo, Department of Physics and Astronomy

Additional Author | Urja Nandivada, University of Waterloo, Department of Physics and Astronomy

Additional Author | Meg Ward, University of Waterloo, Department of Physics and Astronomy

In this paper we discuss efforts to update the undergraduate laboratory curriculum at a large research-intensive university. The revision is motivated by disappointing levels of student satisfaction in traditionally structured labs and by a desire to show undergraduate students the fun, beauty, and excitement of experimental physics. Our goal is to adopt the philosophy of SQILabs, developed by Holmes, Wieman and Bonn, in our laboratory courses at all undergraduate levels. SQILabs focus on using data to develop, test and refine models. They involve iterative experimentation and require students make decisions regarding planning and carrying out an experiment, and interpretation of data. Here we report on efforts in our first-year laboratories which approximately 200 new physics majors take each year. We will summarize the changes we have made to the curriculum and will discuss shifts in student attitudes and improvement in critical thinking as measured on the E-CLASS and PLIC respectively.

AF02 (8:10 to 8:20 AM MONDAY) Planning Prompt Surveys to Encourage Early Completion of Homework Assignments

Contributed – Presenting Author: Zachary Felker, University of Central Florida

Additional Author | Zhongzhou Chen, University of Central Florida

In an earlier study we showed that small amounts of extra credit offered for early progress on online homework assignments can reduce cramming behavior in introductory physics students. This work expands on the prior study by implementing a planning prompt intervention. In the prompt we asked students to what degree they intended to earn extra credit offered for early work on the module sequence, and what their plan was to realize their intentions. The survey was due several days before the first extra credit deadline. We found that students who completed the prompt earned on average 0.6 more extra credit points and completed the modules an average of 1.1 days earlier compared to a previous semester. We detect the impact of the survey by creating a multilinear model based on data from students exposed to the intervention as well as students in a previous semester.

AF03 (8:20 to 8:30 AM MONDAY) Curricular Analytics in Physics

Contributed – Presenting 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. Using that framework, they showed that Engineering programs that were deemed higher quality had curricula and degree plans that were simpler than engineering programs that were ranked to be lower quality. They also propose that curricula that is simpler is more agreeable to students, claiming that a simpler curriculum would be beneficial to student retention. The purpose of this presentation is to determine whether or not this trend holds for physics programs in the U.S. Physics curricula from different universities were analyzed using the methods developed by Heileman et al. to see if there is a correlation between program complexity and program quality.

AF04 (8:30 to 8:40 AM MONDAY) Clicker Question Sequence on Uncertainty Principle: Virtual and In-Person Implementation

Contributed – 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 serves to scaffold and formatively assess student learning. We present findings from the implementation, in consecutive years, of a research-validated Clicker Question Sequence (CQS) on student understanding of the uncertainty principle as it applies to two-state quantum systems. This study was conducted in an advanced undergraduate quantum mechanics course, in both the virtual learning environment of 2020 and the in-person classroom setting of 2021. Students were assessed after receiving traditional lecture-based instruction, and their performance was compared with that on a similar assessment given after engaging with the CQS. We examine and remark on the constant and differing trends observed in the two modes of instruction.

AF05 (8:40 to 8:50 AM MONDAY) Investigating Students' Strengths and Difficulties in Quantum Computing

Contributed – Presenting Author: Tunde Kushimo, Texas Tech University

Additional Author | Beth Thacker, Texas Tech University

The field of quantum computing is presently gaining tremendous attention from governments, researchers, engineers, academics and investors. There is an ongoing push for the development of quantum computers, advances in information technology, and the development of a quantum workforce. This needs to be accompanied by the development of quantum computing courses and curricula and the development and adoption of evidence-based materials and pedagogies to support the education of the next generation of quantum information scientists At Texas Tech University (TTU), we have introduced a course in Quantum Computing and have begun to research student understanding of topics in this field. Our goal is to develop evidence-based materials for the course. We did a series of interviews to identify students' strengths and difficulties in these topics. We report on the results of these interivews and our initial work on the development of supplementary materials for the course.

Session AG: PER: Student Content Understanding, Problem-Solving and Reasoning I

Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Research in Physics Education
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** TBA

AG01 (8:00 to 8:10 AM MONDAY) Realistic Assessment of Students' Mathematical Preparation in Introductory Physics Courses*

Contributed – Presenting Author: David Meltzer, Arizona State University

Additional Author | Dakota H. King, National Heart, Lung, and Blood Institute, National Institutes of Health

Additional Author | John D. Byrd, Arizona State University

We summarize key findings of our six-year investigation into students' mathematical difficulties in introductory physics courses. After administering written and online diagnostic tests to over 7000 students at five campuses of four universities, and carrying out about 90 individual interviews, we find several consistent themes: (1) difficulties with basic pre-college operations involving trigonometry, algebra, and graphing are widespread; (2) replacing numbers with algebraic symbols significantly decreases students' problem-solving success rate; (3) most students lack familiarity with physical units or appreciation for their essential role in physics problems; (4) most students attempt to "arithmetize" algebraic operations by premature substitution of numerical values, decreasing their ability to check physical units or individual steps; (5) difficulties with different types of operations are highly correlated, in that difficulties with trigonometry imply difficulties with algebra, etc.; (6) evidence suggests that students' success on the mathematics diagnostic is closely linked to overall course success.

*Supported in part by NSF DUE #1504986 and #1914712

AG02 (8:10 to 8:20 AM) Exploring the Origins of Physics Student Misconceptions in Mathematics*

Contributed – Presenting Author: John Byrd, Arizona State University

Additional Author | David E Meltzer, Arizona State University

Additional Author | Dakota H King, National Heart, Lung, and Blood Institute, National Institutes of Health

As part of our investigation into physics student's difficulties with mathematical operations, we recently conducted seven additional semi-structured interviews with algebra-based physics students; the interviews incorporated some test items not used in our previous interviews These self-selected students had higher correct-response rates than the much larger random sample that had previously responded to our written or online diagnostic. As found during previous interviews, students frequently "self-corrected" their errors with little or no prompting. For example, 75% of algebra errors in this sample were self-corrected, compared to 46% in our previous, larger interview sample using similar test items. We also found that, when solving for the areas of a triangle and a circle, most students did not consider units without being explicitly prompted. Only two of the seven students provided correct units, with multiple students giving different units for the areas of the two shapes.

*Supported in part by NSF DUE #1504986 and #1914712

AG03 (8:20 to 8:30 AM MONDAY) Exploring the Factors Affecting the Expert-like Scientific Attitudes

Contributed – Presenting Author: Dona Hewagallage, West Virginia University

Additional Author | John C Stewart, West Virginia University

This study investigates the three facets of the Colorado Learning Attitudes about Science Survey (CLASS): personal application, personal effort, and problem-solving. Explanatory Factor Analysis (EFA) is used to understand the suitability of the above item categorization and then Item Response Theory (IRT) to estimate a latent variable capturing expert-like scientific attitudes. Correlations among the variables: the latent variable, the facets, FMCE pretest, and post-test scores, course grade, ACT/SAT scores, and general high school preparation school are calculated. Regression analysis is done to explore what factors explain the variance in each facet and the latent variable.

AG04 (8:30 to 8:40 AM MONDAY) Impact of Mathematical Reasoning on Students' Understanding of Quantum Optics

Contributed – Presenting Author: Paul Justice, University of Cincinnati

Additional Author | Chandralekha Singh, University of Pittsburgh

Additional Author | Emily Marshman, University of Pittsburgh

We report on an investigation in which we compare the conceptual performance of upper-level undergraduates and graduate students, who worked on two different validated Quantum Interactive Learning Tutorials (QuILTs). One of the QuILTs incorporates mathematical reasoning while focusing on helping students develop a good conceptual understanding of quantum optics using a Mach-Zehnder Interferometer with single photons and polarizers. Performance of students who engaged with this "hybrid" (integrated conceptual and quantitative) QuILT is compared with those who engaged with a conceptual QuILT focusing on the same topics without quantitative tools. We find that the posttest performance on conceptual questions of physics graduate students who engaged with the hybrid QuILT was generally better than those who engaged with the conceptual QuILT. For undergraduate students, the results were mixed.

AG05 (8:40 to 8:50 AM MONDAY) Examining Student Reasoning: A Replication Study at an HBCU

Contributed – Presenting Author: John Kelly, Tennessee State University

Physics education researchers agree that the field would benefit from investigations conducted with diverse student populations. At the same time, researchers recognize that most PER studies have been undertaken at institutions with populations not representative of the general population of students taking introductory physics in the United States. This project examines physics teaching and student learning at a Historically Black University, thus contributing to a sparse body of research with this underrepresented population. Specifically, we probed whether patterns of student responses to questions designed to disentangle conceptual understanding, reasoning, and intuition reported in literature would also be observed in our population. The results revealed that our students performed significantly worse than students in the original studies. We propose possible explanations for the observed differences in student performance, discuss challenges encountered in our replication study, and outline strategies for further research.

AG06 (8:50 to 9:00 AM MONDAY) The Evolution of Accuracy and Speed in Online Mastery practice

Contributed – Presenting Author: Andrew Heckler, Ohio State University

Additional Author | Megan N Nieberding, Ohio State University

We present results on a study investigating the evolution of accuracy and speed during repeated practice spanning multiple weeks via an online mastery learning application for skills relevant to introductory physics. The participants were enrolled in algebra or calculus-based introductory physics at a large public research University. We investigated several potentially important factors, including the number and timing of practice trials, gender, ACT math score, submission time before deadline, and growth mindset. We find that mean improvements in accuracy and speed vary with initial practice category performance and student population, consistent with well-documented general learning curves. Further we find that the initial performance gaps between students with low and High ACT math scores and between women and men decreases with practice. We also find that students who procrastinate improved their completion times significantly less than non-procrastinators, even controlling for ACT score, and that mindset did not predict any performance measures.

Session AH: Training Learning Assistants and Graduate Students to be Effective Lab Assistants I

Location: CC: Grand Gallery Overlook G/H **Sponsor:** Committee on Laboratories
Time: 8–9 a.m. **Date:** Monday, July 11 **Presider:** Kasey Wagoner

AH01 (8:00 to 8:30 AM MONDAY) Training Novice GTAs and LAs to Teach ISLE-Based Labs

Invited – Presenting Author: Joshua Rutberg, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

Additional Author | Patrick Makowski, Fairleigh Dickenson University

Since Fall 2019, our introductory physics teaching team has reformed all aspects of our introductory physics sequence using the ISLE-approach. This included our introductory physics labs. These labs are taught by a mixture of full-time faculty, part-time faculty, and graduate Teaching Assistants, supported by undergraduate Learning Assistants. Due to the increased pedagogical demands of this style of teaching compared to teaching traditional lab courses, we have needed to develop new ways to train our instructors and learning assistants. Here we discuss the training needs particular to an ILSE-based lab course, the training we have been able to provide, and some reflection on the performance of our instructors over the past few years.

AH02 (8:30 to 9:00 AM MONDAY) Classroom Observations as Part of TA Training

Invited – Presenting Author: Emily Alicea-Munoz, Georgia Institute of Technology

In large-enrollment introductory physics classes, students spend nearly half of their in-class time supervised by teaching assistants (TAs). Given their essential role as educators, TAs require proper preparation and support. The graduate TA preparation program at the Georgia Tech School of Physics is well-established and based on the integration of pedagogy, physics, and professional development. Classroom observations are an important component of the program, as they give us the opportunity to see TAs in action and give them feedback on what they are doing well and on what they need to improve. In this talk I give a brief overview of our program, the motivation for classroom observations, the steps needed to prepare the observations, and how our TAs have benefited from them. I also include logistical details such as equiPM MONDAYent needed to carry out observations, and what happens to the observation videos after the TAs finish the preparation program.

Session BA: 21st Century Physics in the Classroom II

Location: CC: Grand Gallery A **Sponsor:** Committee on Physics in High Schools
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** TBA

BA01 (9:10 to 9:20 AM MONDAY) 21st Century Physics Integrated into the High School Physics Curriculum

Contributed – Presenting Author: Deborah Roudebush, QuarkNet

This talk will focus on ways to assist high school physics teachers in incorporating 21st century physics side by side with classical topics. The talk will compare the QuarkNet approach with the seven characteristics of effective professional development developed by Linda Darling-Hammond et.al.

BA02 (9:20 to 9:30 AM MONDAY) Lessons from Extra Dimensions: Rotations Were Bivectors All Along

Contributed – Presenting Author: Steuard Jensen, Alma College

Models like string theory inspire exciting questions about physics in higher dimensions. Fundamental concepts like energy and momentum generalize to extra dimensions easily, but angular momentum as traditionally taught depends on the cross product: an intrinsically three-dimensional concept. Instead, even introductory rotational physics can be taught just as easily in terms of "bivectors," which can be visualized as "tiles" with area and orientation whose components form an antisymmetric matrix. Bivectors have historically been discussed mostly in specialized contexts like spacetime classification or geometric algebra, but in most ways they are just as easy to understand as vectors, and they generalize naturally to extra dimensions. Imagine never again watching a student struggle to master yet another right hand rule, never again worrying about the subtle trap of a left-handed coordinate system. Teaching rotational physics in this language opens the door to exploration of higher dimensions, and it's more fundamental as well.

BA03 (9:30 to 9:40 AM MONDAY) Teaching Measurement to Prepare for Quantum Sensing

Contributed – Presenting Author: James Freericks, Georgetown University

The von Neumann theory of quantum measurement involves uniquely entangling the eigenstates of a self-adjoint operator with the pointer states of the experimental apparatus. Then, either wavefunction collapse, or decoherence (due to the macroscopic pointer states) fixes the measurement of the apparatus. Unfortunately, most, if not all, quantum experiments don't operate that way. Instead they are counting experiments, where properties are often inferred from the geometrical set-up of the experiment. In this talk, I will focus on how momentum is actually measured, which usually follows a time-of-flight strategy, that infers the momentum by measuring the position. I will provide examples for how this works and explain why we need to teach a proper measurement theory within undergraduate quantum mechanics classes. Only in this fashion, can we properly prepare our students for future careers in the quantum-enabled workforce, particularly in the area of quantum sensing.

BA04 (9:40 to 9:50 AM MONDAY) Sailing Stones as an Anchoring Phenomenon for Kinematics

Contributed – Presenting Author: Christopher Moore, University of Nebraska Omaha

Long trails terminated by heavy rocks called "sailing stones" were discovered at Racetrack Playa in Death Valley National Park in 1915. It took nearly 100 years for geologists and geophysicists to understand why and how these heavy rocks moved across the dry desert without animal intervention. Published in 2014 in the open-access journal PLOS One, the paper describing the mechanism and motions provides a treasure-trove of authentic and relevant data that can be incorporated into physics lessons. Your students will be able to use real data from recently published journal articles to answer authentic questions in kinematics. You will also learn what representations and data your students can use to bridge phenomena and mathematics, and how to use data tasks to assess kinematics understanding, as opposed to rote algebra skills.

BA05 (9:50 to 10:00 AM MONDAY) Dark Matter Activities as a Phenomenon for MS/HS Standards

Contributed – Presenting Author: Peggy Norris, Black Hills State University / SURF (retired)

Additional Author | Chad Ronish, Black Hills State University / Sanford Underground Research Facility

Physical science standards on electromagnetic and gravitational interactions are sometimes relegated to a chapter in a textbook and may feel to middle and high school students like topics that are old and stale, in other words, settled science. Approaching these standards from a different direction - using current searches for dark matter as a storyline - can spark students' curiosity and engage them in seeing science as a process that is always evolving. Now that we are face-to-face again, we will take the opportunity to explore hands-on activities developed or adapted by the Education and Outreach Department at the Sanford Underground Research Facility around the topics of evidence for dark matter and current dark matter searches.

BA06 (10:00 to 10:10 AM MONDAY) The Development of a Hypersonic Curriculum: Initial Results

Contributed – Presenting Author: Spencer Perry, Indiana Univeristy

Hypersonic flight is a domain that is generally considered to include anything traveling five times or more the speed of sound. At these speeds, unique challenges arise that influence vehicle design. Hypersonic flight is also of national defense interest for most international actors. However, there is little in the way of curriculum to support hypersonic instruction at the K-12 level. I will report on the initial curriculum development results for teaching concepts about hypersonic flight. This curriculum development is being completed through a partnership of the Indiana Univeristy-Bloomington School of Education and the education outreach office at Crane Naval Surface Warfare Center

Session BB: Assessing and Improving Equity in Physics Learning Environments I

Location: CC: Grand Gallery Overlook H **Sponsor:** AAPT
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** TBA

BB01 (9:10 to 9:40 AM MONDAY) Not All Disadvantages Are Equal: Investigating Grades and Motivational Beliefs

Invited – Presenting Author: Sonja Cwik, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Inequitable outcomes in physics courses point to systemic inequities in higher education for students with historically disadvantaged backgrounds and investigations focusing on these can be useful to provide support and create an equitable and inclusive learning environment. Specifically, student grades and motivational outcomes in introductory physics courses can influence their retention in science, technology, engineering, and math (STEM) disciplines and future career aspirations. This study uses data at a large public research institution to investigate the grades earned by students categorized by four demographic characteristics: gender, race/ethnicity, low income status, and first-generation college student status. We find that on average across all years of study, underrepresented minority (URM) students experience a larger penalty to their STEM GPA than even the most disadvantaged non-URM students. In order to further understand inequitable outcomes in introductory physics courses, we discuss an investigation of students' motivational beliefs that show a gender gap.

BB02 (9:40 to 10:10 AM MONDAY) The Effect of Prior Preparation on Students Underrepresented in Physics

Invited – Presenting Author: John Stewart, West Virginia University

This presentation synthesizes several strands of quantitative analysis of the relation of membership in a demographic group underrepresented in physics classes on course outcomes (course grades and Force and Motion Conceptual Evaluation post-test scores) as well as university outcomes (graduation). Differences are explored by gender, underrepresented ethnic or racial minority status, status as a first-generation college student, and rural or urban status. Mediation and moderation analysis show that many differences in course outcomes are largely explained by prior preparation (with some important exceptions), but that the factors influencing differences are not the same for all groups. Survival analysis shows that the patterns of risk of negative college outcomes are not the same for all groups suggesting retention efforts need to be tailored for different demographic groups to maximally retain all students.

Session BC: Being a Student-Ready Physics Course

Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Physics in Two-Year Colleges
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** Kris Lui

BC01 (9:10 to 9:20 AM MONDAY) Asking What Happens

Contributed – Presenting Author: Mark Eichenlaub, Art of Problem Solving

Quantities like force, energy, electric charge, or entropy live in scientific models, not tangible experience. When we ask students to calculate these quantities or use them as givens in a problem, we are training familiarity with our models, but often sacrificing contact with the real world. I will discuss how I rewrote several of my own model-centric problems to instead "ask what happens" - to ask only about things students can directly experience. The rewritten problems aimed to bring quantities like force, energy etc. into our analysis with a clearer purpose. They also allow for extended classroom discussion because real world effects that are ignored in the model-centric versions become directly relevant to the rewrites. Finally, in "asking what happens," I also opened myself up to being wrong in new ways, a move that could lead to a more reciprocal problem solving culture between instructors and students.

BC02 (9:20 to 9:30 AM MONDAY) Eliminated Due Dates and the Result Shocked Me

Contributed – Presenting Author: Raeghan Graessle, William Rainey Harper College

I removed all deadlines from homework, projects, and labs from my physics classes. The results shocked me! My overall percentage of finished work went up significantly and students were extremely positive about the policy. But then I applied it to the calculus-based Modern Physics Class and all heck broke loose. In my talk I'll present a quantitative analysis comparing work completion under strict deadlines vs this radical method. I'll share student comments and opinions about the new policy and also what I learned about my own grading and ability to let go and trust my students. I'll discuss major differences between my life-science students and my engineering students and how they dealt with this freedom. I'll end with how this experiment has changed the way I assess my courses.

BC03 (9:30 to 9:40 AM MONDAY) Reflections on an Initial Implementation of Mastery-Based Testing

Contributed – Presenting Author: Julia Kamenetzky, Westminster College (Salt Lake City, UT)

Traditional grading practices average assessment performance over time, disincentivizing the study of previously-tested material and negatively impacting students who begin the course with a different skill set than their peers but improve over time. Here, I share reflections on my first time implementing a form of specifications-based grading called mastery-based testing in a mathematical methods course for chemistry and physics majors. In this course, a set of about twenty learning goals were assessed individually (one question and one score per learning goal) and students were only awarded credit for demonstrating the achievement of that goal. No partial credit was awarded, but students could reassess any previous learning goals multiple times throughout the semester. Though such a system has logistical challenges, it allows students to replace previous poor scores with new scores that represent their eventual understanding. I will offer advice and resources for successful implementation in your physics classroom.

BC04 (9:40 to 9:50 AM MONDAY) Introductory Physics Students' Concerns about Transitioning to College

Contributed – Presenting Author: Sarat Lewsirirat, Department of Physics, University of Illinois Urbana-Champaign

Additional Author | Jianna Torcende, Department of Physics, University of Illinois Urbana-Champaign

Additional Author | Eric Kuo, Department of Physics and Department of Curriculum and Instruction, University of Illinois Urbana-Champaign

Additional Author | Gary E. Gladding, Department of Physics, University of Illinois Urbana-Champaign

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

As part of a course transformation project aiming to ease undergraduate students' transition to college, we sought to understand students' concerns at the start of their college careers. As part of a belonging activity done in week 1 of a Fall 2020 introductory physics course (online), students wrote about their transition-to-college concerns. Although academic concerns were a major category, the results show that there are several non-academic types of concerns: social, task management, decision-making, and having a good college experience. Some of the most common concerns are about how to be organized given overwhelming online learning tools, how to live away from home, how to manage time, and what activities to pursue during their college years and professional futures. As future work, we plan to explore how an introductory physics course could provide support or help mitigate worry relating to these concerns.

BC05 (9:50 to 10:00 AM MONDAY) Un-grading Physics Classes to Support all Students Succeeding

Contributed – Presenting Author: Benjamin Pollard, Worcester Polytechnic Institute

Additional Author | Benjamin Petkie, Worcester Polytechnic Institute

Evaluation of students is central to mainstream US society's approach to formal education. In physics classrooms, grading is typically the primary context for evaluation. Grading can serve to rank students, gatekeep, and influence students' careers and livelihoods, all in inequitable ways. It can also serve as a channel for formative feedback. Relatively recently, some educators have been turning a critical gaze towards grading and evaluative practices overall. One collection of ideas that has emerged falls under the umbrella of "un-grading," the practice of de-emphasizing or removing grades as a motivating factor in formal education settings. In this talk, I present an overview for un-grading approaches and their connections to equity and supporting student success. I also describe preliminary efforts by myself and others at Worcester Polytechnic Institute to implement un-grading in their courses, and share preliminary insights from a large intro physics course and from an upper-division physics lab course.

BC06 (10:00 to 10:10 AM MONDAY) The "Spaghetti" Approach to Equitable, Culturally Responsive, and Accessible Classrooms.

Contributed – Presenting Author: Elizabeth Schoene, South Seattle College

Additional Author | Abigail R Daane, South Seattle College

Students come to our classes with varied life experiences, physics backgrounds, needs, and interests that enrich our classrooms. Through our many teaching experiences (throwing spaghetti - or perhaps rice or quinoa! at the wall) - we know that just one kind of teaching does not work for all students! We have developed a strategy of exploring concepts through a multitude of activities, pedagogies, and curricula, such as community building & inquiry activities, peer instruction, and modeling. These different points of entry, experiences, and perspectives create an environment where students flourish. In this talk, we will outline this "throwing spaghetti, to see what sticks" approach, and how it engages students with the material and each other in meaningful ways.

Session BD: Best Practices in Educational Technology I

Location: CC: Grand Gallery B **Sponsor:** Committee on Educational Technologies
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** Duncan Carlsmith

BD01 (9:10 to 9:20 AM MONDAY) Using a Capstone Experience in the Introductory Physics Classes

Contributed – Presenting Author: Tatiana Krivosheev, Clayton State University

Additional Author | Dmitriy Beznosko, Clayton State University

Additional Author | Alexander Iakovlev, Community Christian School

We present the process and outcomes of introducing a capstone project to the first semester of calculus-based Introductory Physics sequence suitable for both in-class and remote learning. At the end of a semester, students are offered a variety of physics situations to thoroughly investigate and explain by using the knowledge, tools, and techniques that they have gained during the first semester of physics lectures and mastered in laboratories. Topics for the project are curated to provide a possibility of multiple insights by utilizing energy considerations, force-acceleration approach and numerical simulations, and investigated through videos suitable for video analysis. Students are encouraged to work in small groups to boost the peer to peer learning. The project culminates in a poster presentation which provides a summative assessment of the learning gains. The project is introduced as a part of the general course redesign funded by the Affordable Learning Georgia grant.

BD02 (9:20 to 9:30 AM MONDAY) Augmented Reality Models of Physics Concepts

Contributed – Presenting Author: Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Ed

Many undergraduate students find it difficult to visualize 3-D concepts in physics and engineering courses. There is a need for context-specific spatial visualization activities to help students connect 2-D representations to 3-D models. We have assembled an interdisciplin-

ary team of undergraduate physics/computer science research students together with physics and PER faculty to create 3D augmented reality (AR) models of physics concepts for astronomy, kinematics, mechanics, electricity, magnetism and mathematical physics. AR models provide students with an opportunity to convert 2-D representations to 3-D visualizations. Students and instructors can utilize these AR apps in a variety of situations including for use within lectures, problem solving sessions or labs either within in-person or remote instruction.

BD03 (9:30 to 9:40 AM MONDAY) Laboratory Instruction Using Radon and Its Progeny

Contributed – Presenting Author: Jeffrey Radtke, Department of Medical Physics, University of Wisconsin

Additional Author | Kendall E Barrett, Department of Medical Physics, University of Wisconsin

Additional Author | Jonathan W Engle, Department of Medical Physics, University of Wisconsin

Acquiring an unnecessary radioactive source inventory is discouraged in the 21st century. A laboratory using radioactive sources present in our environment was developed to observe nuclear decay and transport phenomena. Progeny of radon-220 and radon-222 were collected using electrostatic techniques and observed with both a NaI(Tl) well counter spectrometer and a cloud chamber. The spectrometer recorded six ten-minute spectra, followed by four five-hour spectra, which were used to identify radon progeny based on decay emissions' characteristic energy and radionuclide half-lives. Radon progeny deposited on the end of a wire formed a short-lived, pointlike source of high energy alpha particles for the cloud chamber. Radon-220 itself was introduced into the cloud chamber, so that gas diffusion, linear energy transfer, and radioactive decay chains could be observed and discussed. A video presentation of these experiments was created for remote instruction during the pandemic.

BD04 (9:40 to 9:50 PM MONDAY) Nevertheless, She Persisted: The Impact of Persistence in Computational Education

Contributed – Presenting Author: Megan Schwartz

As computation grows as a tool for scientists and engineers, there has been an increased interest in how to support STEM majors most effectively in the development of computational practices. It is important to support the development of computational practices for undergraduate students within majors like physics and mathematics as they have unique opportunities to operationalize computation in multiple contexts. We analyze the significance of the computational disposition "persistence" for an individual and how that impacts the group members around her. We present a representative case study of an individual who engages her group members through consistent persistence. We seek to propose a potential relationship between persistence and other computational thinking practices. Furthermore, we highlight opportunities for educators to encourage persistence in individuals that in turn serves their group. Through this analysis, we consider how creating collaborative environments in computationally integrated environments proves productive for students' tackling computational activities.

BD05 (9:50 to 10:10 AM MONDAY) Quantum Science in Visible Range

Contributed – Presenting Author: Y Vijay, IIS deemed to be University, Jaipur

In science teaching at the school level and higher, it is challenging task to express the nano science and technological the fundamental interaction and collective behavior could be demonstrated through modeling where the quantum science principles and phenomena could be bought in the visible range and human perception. We have designed several models to illustrate following in particular like, Vander wall force, Dipole interaction, equilibrium in a plane, atomic configurations, Bohr orbitals, Raman Effect, Rutherford scattering, Modes of Molecular vibrations. These are all mechanical models working at the low frequency range depicting the quantum phenomena in visible range. In Raman the energy transfer as a function of phase of the pendulum is used. For Bohr orbitals the stationary waves in circular loops are setup. Simple molecules like, water, methane and ammonia are made using balls and springs to show modes of vibrations.

BD06 (10:00 to 10:10 AM MONDAY) Physics Teaching at Teams Combined with SharePoint and Moodle

Contributed – Presenting Author: Hannu Turunen, Metropolia University of Applied Sciences

I will show how to build a flexible and easy-to-update physics learning environment using the best parts of MS Teams, SharePoint and Moodle. MS Teams works well for informing, holding interactive lessons, and recording them. In SharePoint, you can build visually great learning material to which you can link videos and other material from the Internet. Moodle offers a wide variety of assignments that are automatically checked. With the help of Teams, these three platforms are combined into one, creating a diverse learning environment to support physics learning. SharePoint and Moodle provide easy sharing and co-development of material and assignments. This idea was developed during remote learning but is equally applicable to face-to-face teaching.

Session BE: Challenges Facing Women in Physics (AIP Report)

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Women in Physics

Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** Shahida Dar

BE01 (9:10 to 9:40 AM MONDAY) Challenges Facing Women in Physics

Invited – Presenting Author: Anne Marie Porter, American Institute of Physics

Although the number of women earning physics degrees has increased over time, women remain under-represented in the field, earning 21% of physics bachelor's degrees, 19% of physics doctorates, and 19% of faculty positions. Women also encounter more challenges in academic departments and physics programs. Using survey data collected by the AIP Statistical Research Center and the Gender Gap in Science project, our results show that compared to men, women in academia were more likely to report fewer resources, less confidence, less satisfying mentor relationships, and a less positive work climate. When we compared women's experiences before and during the Covid-19 pandemic, we found that women in academia were more likely to struggle with burnout, mental health challenges, work-life balance, and performing research activities. These results can be used to better support women in physics, especially as academic institutions continue to cope with the effects of the pandemic.

Session BF: Computation and Modeling to Non-science Majors II

Location: CC: Grand Gallery C **Sponsor:** Committee on Educational Technologies
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** Jay Wang

BF01 (9:10 to 9:20 AM MONDAY) Python Sub-skills in a Physics for Engineers Class

Contributed – Presenting Author: Anna Klales, Harvard University

Over the past five years we have incorporated Python into lectures and labs for our introductory physics for engineers sequence. Learning goals range from using Python as a calculator to basic differential equation solving and data analysis for experimental results. Here we present some of our most popular project ideas and examples of sub-skills, where complex topics are broken down into manageable pieces for students. Insights from course data and student feedback are also shared to encourage physicists who are considering adding Python to their introductory physics curriculum.

BF02 (9:20 to 9:30 AM MONDAY) Modeling Diffusion for Life Science Majors by Incorporating Computation

Contributed – Presenting Author: Kirtimaan Mohan, Michigan State University

Additional Author | Kathleen Hinko, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

We present on updates to a unit on diffusion in an Introductory Physics for the Life Sciences (IPLS) course. We will describe the series of computational tasks designed to build up students' understanding of random motion and diffusion and contrasting it with coherent motion. These tasks are embedded in an integrated lab-lecture (studio style) introductory physics course that meets the needs of life science students. Our design of this course focuses on incorporating computational simulations that model complex biological phenomenon and complement empirical lab investigations. In this presentation we will describe changes that we have made to the diffusion computational unit and how those changes supported student understanding and engagement. We also add in an optional module that introduced students to quantum computers that are used to simulate random walk.

BF03 (9:30 to 9:40 AM MONDAY) Reinventing the STEMcoding Project through the Pandemic*

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

The STEMcoding Project began in 2017 with the launch of a youtube channel featuring coding tutorials on the physics of classic video games. Since then the content has grown and during the pandemic we redesigned nearly all of our activities to give students instant feedback on their codes rather than relying heavily on the instructor to troubleshoot. The pandemic also inspired us to create our own object tracking code that works through the browser on video data so students can perform simple experiments at home and analyze them. Both the object tracker and the instant feedback take advantage of javascript and a library called p5.js. I will also briefly describe coding activities that we designed for 9th grade physical science that also work well in college non-major classes. Many of these activities appear on the PICUP site (compadre.org/PICUP)

*The STEMcoding Project received funding from the 2021 AIP Meggers Award.

BF04 (9:40 to 9:50 AM MONDAY) Video Evidence of Computational Thinking Practices in High School Physics*

Contributed – Presenting Author: Daniel Weller, University of New England

Additional Author | Theodore E. Bott, Michigan State University

Additional Author | Marcos D. Caballero, Michigan State University

Additional Author | Paul W. Irving, Michigan State University

Physics classes with computation integrated into the curriculum are a fitting context for investigating computational thinking. In this presentation, we propound a framework for exploring CT in introductory physics courses. The framework, which was developed by reviewing relevant literature and acquiring video data from high school classrooms, comprises 14 practices that students could engage in when working with Glowscript VPython activities. For every practice, we have discovered in-class video data to exemplify the practice. Given time constraints, this presentation will only highlight the most striking examples of common CT practices. We will also discuss preliminary findings from our data analysis based on different classrooms/instructors, computational activity designs, and student group compositions. In doing this work, we hope to provide ways for teachers to assess their students' development of computational thinking and give physics education researchers a foundation to study the topic in greater depth.

*University of New England, NSF DRL-1741575

BF06 (10:00 to 10:10 AM MONDAY) A Long-term Assessment of Computational Activities in an Astronomy Course

Contributed – Presenting Author: James DiCaro, Illinois State University

Additional Author | Raymond Zich, Illinois State University

Additional Author | Rebecca Rosenblatt, National Science Foundation EHR/HRD

This study explored the effectiveness of integrating computational exercises as an instructional tool in a general education astronomy course over four semesters. Fifteen spreadsheet-based computational exercises were designed and incorporated into a single-semester astronomy course to complement the existing active learning curriculum. Computational exercises were added to improve students' understanding of concepts, influence connecting concepts with the mathematics, and support the association of science with prediction. As most new curricula only report one or two semesters of results before widespread introduction occurs, the longer-term assessment of these instructional interventions provide a better indication of effectiveness of the new curriculum. Student learning pre to post was measured with the TOAST and LPCI. Additionally, student survey data was collected to investigate student attitudes toward computational exercises and overall perceptions of the course. Assessment revealed TOAST correctness gains of 20%, LPCI correctness gains of 29%, and overall positive attitudes towards the computational activities.

Session BG: PER: Curriculum and Instruction II

Location: CC: Grand Gallery Overlook E/F **Sponsor:** Committee on Research in Physics Education
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** TBA

BG01 (09:10 to 0 9:20 AM MONDAY) What Do Large Introductory Physics ISLE-based Courses Look Like?

Contributed – Presenting Author: Diane Jammula, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Patrick Makowski, Rutgers University - Newark

Additional Author | Josh Rutberg, Rutgers University - Newark

In Fall 2019, we reformed all of the introductory physics courses and components at Rutgers, Newark using an ISLE-approach. Each course includes lecture and recitation, what we call "Large Group Meeting" and "Small Group Meeting," and lab. 450 students enroll in these courses each semester. ISLE is a constructivist approach where students learn physics by doing physics. How do we engage a lecture hall of 150 students in experimentation? What happens in Small Group Meeting? How are labs designed so students learn practices of science? We present the curriculum and structure of our ISLE-based courses to demonstrate what constructivism can look like in large lecture courses.

BG02 (09:20 to 9:30 AM MONDAY) How Students Evaluate their Work in an ISLE-based Physic Course

Contributed – Presenting Author: Sheehan Ahmed, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

Additional Author | Joshua Rutberg, Rutgers University - Newark

Additional Author | Patrick Makowski, Rutgers University - Newark

We reformed our introductory physics courses using ISLE in an effort to teach students to think like scientists. In this approach, students develop physics knowledge by observing phenomena, creating explanations, and testing ideas. Students then apply knowledge to solve problems. Open-ended problems are scored using a rubric with five rows: Sketch, Representation, Problem Solving Procedure, Explanation, and Evaluation. Evaluation requires making sense of physics concepts and one's own work to determine if an answer or idea is correct. In this presentation we analyze student open-ended submissions to see ways in which they evaluate their work and which methods are most effective, with hopes of better teaching this skill.

BG03 (09:30 to 09:40 AM MONDAY) Teaching a Planned Constructivist ISLE Curriculum in a Student-centered Way

Contributed – Presenting Author: Patrick Makowski, Rutgers University - Newark

Additional Author | Sheehan Ahmed, Rutgers University - Newark

Additional Author | Diane Jammula, Rutgers University - Newark

Additional Author | Joshua Rutberg, Rutgers University - Newark

All introductory physics courses and components at Rutgers, Newark are taught using an ISLE-approach. 450 students enroll in these courses, taught by 10 instructors with help from 10 Learning Assistants. ISLE is a constructivist approach, where students build physics knowledge by engaging in practices of science. Each lesson has a clear plan and goals, yet we aim to teach such that the course is driven by students' ideas. Centering students' ideas while already having a plan is a challenging skill. In the presentation, I observe an expert ISLE instructor to learn exactly what strategies they use such that the planned lesson flows from students' thinking. These strategies are useful to anyone teaching a research-based planned curriculum to avoid the trap of answering one's own questions.

BG04 (9:40 to 9:50 AM MONDAY) Engagement in Collaboration and Teamwork Using Google Colaboratory

Contributed – Presenting Author: Alexandra Werth, University of Colorado - Boulder

Additional Author | Kristin Oliver, University of Colorado - Boulder

Additional Author | Colin G. West, University of Colorado - Boulder

Additional Author | H. J. Lewandowski, University of Colorado - Boulder

Google Colaboratory (Colab) is a multiuser environment that allows anybody to write and execute python code through their browser. With recent calls to increase computation in physics, Colab has the potential to be a valuable tool to allow students to collaboratively code. We examine how student teams navigated collaboration challenges related to using Colab in an online environment as they conducted data analysis for a course based undergraduate research experience. We use a socially-shared regulation of learning framework to understand the challenges, regulations, and goal attainment students discussed related to their experience programming in teams online. We found that students struggled with version control issues---this led to the use of socially-shared regulatory strategies including assigning and rotating roles as well as needing clearer communication. Highlighting students' experiences can help inform instruction on how to promote productive collaboration in coding environments both online and in person.

BG05 (9:50 to 10:00 AM MONDAY) Investigating Student Performance in a Hybrid-Flipped Modern Physics Course

Contributed – Presenting Author: Scott Yarbrough, University of Texas at Arlington

Additional Author | Ramon Lopez, University of Texas at Arlington

The effectiveness of the flipped classroom and hybrid-flipped (partially flipped, partially lecture-based) method of instruction has been studied for lower-level undergraduate physics courses, and it has been shown to increase student understanding of introductory material in physics. However, few studies have been done for upper-level undergraduate courses, and even fewer have been done for virtual courses. We have investigated a fully virtual, hybrid-flipped Modern Physics course and compared student performance to the same hybrid-flipped course with the synchronous portion offered in-person. We will present preliminary results of this study.

BG06 (10:00 to 10:10 AM) Improving Student Understanding of the Operational Definition of Electric Field*

Contributed – Presenting Author: Safana ismael, North Dakota state university

Additional Author | Mila Kryjevskaia, North Dakota state university

Additional Author | Andrew Boudreaux, Western Washington university

Additional Author | MacKenzier R. Stetzer, University of Maine

Operational definitions play an important role in all sciences, from psychology to physics. Yet, students often struggle to understand their applications or practical significance. For instance, research indicates that introductory physics students often struggle to apply the operational definition of an electric field based on the expression E=F/q. Some students have difficulties analyzing how E, F, and q are affected by a specific change (e.g., an increase in the magnitude of the test charge). In this talk, we will describe research to disentangle three aspects of student thinking that impact performance in this context: intuition, conceptual understanding, and mathematical reasoning. We will describe two separate instructional approaches, developed to leverage different productive aspects of student thinking, and will discuss the results of their implementations.

*This material is based upon 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

Session BH: Using Desmos, Projects in the Physics Classroom

Location: CC: Grand Gallery Overlook G **Sponsor:** Committee on Physics in High Schools
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** Matthew Bryant

Speakers:

Kelly O'Shea, Elisabeth Irwin High School (LREI)

Michael Friedman, Somerville High School

Session BI: Remembrance and Honoring Robert Beck Clark and Warren Hein

Location: CC: Grand Gallery Overlook E **Sponsor:** AAPT **Time:** 9:10–10:10 a.m.
Date: Monday, July 11 **Presider:** TBA

Effective Undergraduate Departments: Curriculum, Cohesion, and Career Pathways

Location: H: Pantlind Ballroom **Sponsor:** AAPT
Time: 9:10–10:10 a.m. **Date:** Monday, July 11 **Presider:** Matthew Bryant

This workshop will discuss effective practices in creating healthy undergraduate departments. Topics will include curriculum development, student/faculty cohesion, and how to present career pathways to students in 2022.

PLENARY: Seeing Out of Both Eyes

By Ed Galindo

Ed Galindo

The topic of my talk will be inclusion. I will define inclusion as one of acceptance. An acceptance of at a minimum, of at least a fair "listening too".

This would mean a listening to not only other ideas, but listening to other people's point of view on all sorts of things including life. Listening to a different culture than yours. Listening to the community where you teach at. Listening to your students. Finally, listening to your heart and understanding what it is telling you.

This concept has been talked about and written about by myself and others to also mean "two eyed seeing" and I have personally added "two ears listening". Really listening to others is not as easy as it sounds. I will be giving examples of what I mean during this talk.

Come and "listen" it will be fun!

Monday, July 11

11 a.m.–12 p.m.

Hotel: Ambassador Ballroom

AWARDS: Doc Brown Futures Award: Debbie Andres – Finding My Physics Teaching Family

Debbie Andres

I did not know how much of an impact my introductory physics professor would have on me. Learning from her inspired me to think about the difference I could make as a physics educator. This path led me to meet some incredibly motivated and passionate teachers. Familial relationships are incredibly important to me and it did not take long before I viewed these colleagues as my immediate physics family. As I learned more about AAPT and its membership, I began to view the organization as my extended family. And just like any family, we learn, grow, and work together to be the best versions of ourselves. As an early career member, I am still finding my place at AAPT. I constantly wonder how I can help or how to share this experience with others. The way I view and interact with the physics teaching community guides how I approach challenges and design solutions. This talk is a reflection of my experiences through the lens of a high school physics teacher navigating AAPT and the extended physics teaching community. I will share how I found my physics teaching family and my commitment to making AAPT a source of family for others.

Monday, July 11

11 a.m.–12 p.m.

Hotel: Ambassador Ballroom

Session CA: Art and Science of Teaching

Location: CC: Grand Gallery B **Sponsor:** Committee on Physics in Undergraduate Education
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** Andrew Gavrin

CA01 (1:00 to 1:30 PM MONDAY) Inviting Undergraduates into the Art and Science of Teaching

Invited – Presenting Author: Rachel Scherr, University Of Washington Bothell

In Learning Assistant (LA) programs, undergraduate students work together with faculty to make classes more interactive. At the University of Washington's Bothell campus, a primarily undergraduate campus where about half of the students are the first in their family to attend college, we are creating an experience in which undergraduate students have the knowledge, skills, agency, and community to make physics teaching and learning more effective, equitable, and engaging. As students from diverse backgrounds learn to support student-centered instruction, they form an inclusive network of LAs and faculty who support each other's development as physics educators. In this talk, I will share what my LAs and I are learning from each other as we explore the art and science of teaching together.

CA02 (1:30 to 2:00 PM MONDAY) The Art and Science of Teaching with PhET Simulations

Invited – Presenting Author: Katherine Perkins, University of Colorado Boulder

From the beginning, PhET simulations and resources have worked to embody the results of education research in their design and to prioritize flexibility and teacher agency in how they are used in teaching and learning. That is, baking in the science, while respecting and enabling the art, of teaching. In this talk, I will highlight rich examples of these approaches, and introduce several initiatives at PhET where we are building on these traditions. Our PhET-iO initiative allows customization of sims and provides access to back-end data. Our PhET Global initiative is focusing on teacher leadership and community in Latin America and Africa. And, our newest work will give teachers and learners access to adjustable sources of error and uncertainty in sims.

CA03 (2:00 to 2:30 PM MONDAY) An Experiment-First and Inclusive Approach to Teaching Introductory Physics

Invited – Presenting Author: Mario Belloni, Davidson

In the Fall of 2019 with support from a HHMI Inclusive Excellence grant, the Physics Department at Davidson College changed how our introductory physics courses were taught. The traditional format of 3 one-hour lectures and 1 three-hour laboratory per week was converted into a studio format of 3 two-hour class meeting per week in an integrated laboratory-classroom setting. Unlike the standard studio format, our courses use an "experiment-first" approach to each class meeting. In this talk we will discuss the how this approach has worked, focusing on inclusivity, how the approach worked during pandemic-affected semesters, and how these changes are being adopted throughout our entire physics curriculum.

Session CB: Assessing and Improving Equity in Physics Learning Environments II

Location: CC: Grand Gallery A **Sponsor:** Committee on Women in Physics
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** Alexandru Maries

CB01 (1:00 to 1:30 PM MONDAY) The Importance of Inclusiveness of Learning Environment in Promoting Equity

Invited – Presenting Author: Yangqiuting Li, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Issues related to why women are underrepresented in physics have been investigated from various angles. Motivational factors, such as physics self-efficacy have also been shown to influence students' persistence and retention in physics. In this presentation, I will summarize our quantitative and qualitative findings showing that inclusiveness of learning environment plays an important role in promoting equitable academic and motivational outcomes. Our findings highlight the role of instructors in creating an inclusive and equitable learning environment. An ecological-belonging intervention will also be discussed to illustrate the viability of an ecological approach to fostering equity and unlocking student potential.

CB02 (1:30 to 2:00 PM MONDAY) TEAMUP: The Time is Still Now...Two Years Later

Invited – Presenting Author: Arlisa Richardson, Chandler-Gilbert Community College

This talk will include an overview of the AIP TEAMUP research project, "The Time is Now", which provides systemic changes to increase African Americans with Bachelor's Degrees in Physics and Astronomy. As the report enters its third year of publication, it has influenced academia and national policy and continues to serve as a guide for faculty, administrators, and others who want to make impactful changes. Highlights from the report's recommendations offer best practices that can be implemented on campuses, with student organizations, within departments, and in the classrooms to address equity issues in physics.

Session CC: Astronomy Paper

Location: CC: Grand Gallery C **Sponsor:** Committee on Space Science and Astronomy
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** TBA

CC01 (1:00 to 1:10 PM MONDAY) Calculating Roche Limit of a Planet Moon System

Contributed – Presenting Author: Puneeth A

If we take a planet moon system and wish to calculate Roche limit we would require the information of masses of planet and moon and radius of the moon and its circular orbit radius Balancing the forces by centrifugal force ,gravitational force due to the moon and gravitational force due to planet we can further more using the taylor's approximation to estimate as to make it simpler it yields us R=r(3M/m)^{1/2} where R is the limit where moving even more closer disintegrates the body , where r is the radius of moon, M is the mass of planet ,m is the mass of moon .

CC02 (1:10 to 1:20 PM MONDAY) Augmented Reality Visualizations for Teaching Lunar Phases

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

Additional Author | George Hassel, Siena College

Additional Author | Michele McColgan, Siena College

Visualizing Lunar Phases requires that each individual to be able to place themselves inside the Earth/ Moon/ Sun system from both a horizon perspective as well as a solar system perspective. To aid with this visualization and allow individuals to both manipulate and explore the observed phenomenon, we have created a series of Augmented Reality (AR) visualizations to help teach Lunar Phases. We will present these visualizations in this talk as well as provide ideas on how these visualizations can be implemented into the astronomy 101 courses.

CC03 (1:20 to 1:30 PM MONDAY) Improvements on the Attractive Mass Discussion

Contributed – Presenting Author: Rolex Rao, future Start & Candle Light

Just Add some improvements for the previously presented result in the winter meeting 2022. I will add more details later since I need to outrun the deadline today.

CC04 (1:30 to 1:40 PM MONDAY) Modern Eddington Experiment

Contributed – Presenting Author: Toby Dittrich, Portland Community College

In 2017, students from Portland Community College performed the Modern Eddington Experiment during the total eclipse crossing the nation, and became the first students in history to measure the curvature of space by determining the Einstein Coefficient. Now in 2024, with even better equiPM MONDAYent, teams are being recruited for performance of the experiment at a wonderful spot in central Mexico in April 2024. With four teams committed already, you to can involve your students in this extraordinary international research experience. We plan to perform the experiment more accurately than ever done before! This talk will show you how to do this. The long range plan is to make the Modern Eddington Experiment a routine experiment in general relativity for the Advanced Lab courses at many schools during the future eclipses in 2026 and 2028 and beyond.

CC05 (1:40 to 1:50 PM MONDAY) Does a Planetarium Show Achieve its Learning Goals for Audiences?

Contributed – Presenting Author: Jesica Trucks, Abrams Planetarium, Michigan State University

Additional Author | Shannon Schmoll, Abrams Planetarium, Michigan State University

Additional Author | Kathleen Hinko, Department of Physics and Astronomy, Michigan State University

The Big Astronomy Project created a planetarium show and extended engagement activities with the intention to promote learning both in and beyond the dome. The project was designed with a specific set of learning goals to be addressed across the different project elements: 1) the importance of Teamwork in astronomy 2) how Chile is important to astronomy 3) the Multi-wavelength aspect of astronomy 4) the importance of Indigenous Knowledge. Data was collected from interviews and surveys taken from both virtual 360-degree YouTube streams and in-person planetarium shows. The show was successful in conveying the learning goals based on how audiences responded to questions about what they learned from the show and live events. We also explore if there are any differences between in-person and online audiences.

Session CD: Diversity, Equity, and Inclusion: Theoretical Frameworks and Methodologies

Location: CC: Grand Gallery Overlook G **Sponsor:** Committee on Diversity in Physics
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** Alexis Knaub

CD01 (1:00 to 1:10 PM MONDAY) White Male Physicists Sense-making Around Equity in STEM

Contributed – Presenting Author: Melissa Dancy, Western Michigan University

Additional Author | Apriel K Hodari, Eureka Scientific

Additional Author | Charles Henderson, Western Michigan University

Additional Author | Nanah Apkarian, Arizona State University

Additional Author | Estrella Johnson, Virginia State University

While the majority of white men in physics value racial and gender equity, they frequently engage in patterns of thought, speech, and action that undermine these values. We use data from two studies to highlight some of these patterns. One study is based on a large survey of faculty (n=1023) and one based on intensive interviews of white male faculty and graduate students (n =27). Identifying and naming these patterns can help researchers, advocates and white men become aware of these patterns and work to address them. For example, they view inequity as happening outside their sphere of influence, minimize its impacts, and show little understanding of the experiences of those around them of different demographics.

CD02 (1:10 to 1:20 PM MONDAY) Disabled Students' Narratives: The Epic, The Tragedy, and The Surreal

Contributed – Presenting Author: Daniel Oleynik, University of Central Florida

Additional Author | Erin Scanlon, University of Central Florida

Additional Author | Jacquelyn Chini, University of Central Florida

In this study, we present interviews with disabled physics students to draw attention to their experiences in the physics community, and the barriers and supports that they experience as they advance through their physics careers. Using a methodology of narrative analysis, we identify themes within and across the stories told by participants. Narratives are often created to explain the unexpected and solve a problem. In the physics community, disabled students find their differences (i.e., disability/impairments) are often positioned as unexpected and a problem to be solved. We use narrative analysis to humanize disabled physics students and highlight their lived experiences of progressing through the physics community over their perceived deviation from the physics "norm". From this, we create resources for physics mentors to increase their knowledge and understanding of disabled physics students' experiences and how to support accessibility and inclusion in the physics community.

CD03 (1:20 to 1:30 PM MONDAY) Queering Methodologies in Physics Education Research

Contributed – Presenting Author: Madison Swirtz, University of Utah

Additional Author | Ramón Barthelemy, University of Utah

When we talk about "queer theory" in STEM education research, we often use it as a synonym for studying LGBT+ students or queer issues. However, queer theory and queer methods can be applied to discipline-based education research far more broadly. In this presentation I introduce a unique perspective on "queering" quantitative and qualitative research methods and highlight some of the ways these methods are already compatible with the goals of physics education research. This will include discussions of deconstructing binaries, empowering participants in the research process, and reimagining study design to attain novel insights about the experiences of physicists.

CD04 (1:30 to 1:40 PM MONDAY) A Critical Discourse Analysis Framework for Physics Education Research

Contributed – Presenting Author: Stephanie Williams, University of Maryland

Additional Author | Jennifer Radoff, Univ of Maryland-College Park

Additional Author | Chandra Turpen, Univ of Maryland-College Park

Critical Race Theory is in the forefront of educational policy debates across the country, with different factions arguing both for, and against, the need for critical studies, and honest accounts of history in public education. While debates are new, critical studies have existed for years, and Critical Discourse Analysis is a powerful analytical framework that can expose how power structures of white supremacy are constructed in physics spaces, and how those constructs can be challenged. In this talk, I will first summarize key CDA literature, then go through examples using physics faculty discourse from an online learning community designed to support physics faculty implementing a research based curriculum. The analysis will highlight how what a "good student" means is negotiated and reconstructed by faculty, and how these characterizations reinforce deficit narratives in science. Finally, I discuss the need for CDA in PER more broadly.

CD05 (1:40 to 1:50 PM MONDAY) Analyzing and Representing Observational Fieldnotes through Sketching

Contributed – Presenting Author: Laura Wood, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

In a narrative analysis study, we used fieldnotes as a central data source by drawing pictures from the textual descriptions. This was a useful way of synthesizing the fieldnotes into representations, and analyzing them. There are affordances and limitations to this method, but they vary based on the questions one must consider when constructing the images. These questions are a form of analysis themselves because the researcher must decide what critical elements of the environment should be included in the drawing. For example, when drawing people, the researcher needs to ask if they are accurately representing the demographics of the group of people, and if they are representing the specific individuals how they would want. We will share the method we used in our narrative analysis and examine what we were able to learn from a reconstructed visual representation of our fieldnotes.

Session CE: Educational Technology as a Double-edged Sword

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Educational Technologies
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** Katie Ansell

CE01 (1:00 to 1:10 PM MONDAY) Utilizing Perusall Collaborative Reading to Facilitate Learning in Introductory Physics

Contributed – Presenting Author: Jessica Bickel, Cleveland State University

When assigned textbook reading in introductory physics, few students read before coming to class. This work examines the use of Perusall at a public urban university. Perusall is a collaborative reading of the textbook where students write comments, ask questions, and reply to their classmates. Students are graded on their engagement with the text rather than their comprehension as is done with traditional reading questions. The comments can then be used in a JiTT way and brought to class to focus the classroom discussion and learning. This study covers six sections of calculus-based introductory physics led by four faculty members. Student survey data shows that the students are more likely to read with Perusall compared to traditional reading with questions. Further, MPEX results show an increase in students' attitudes towards reading and the textbook. Finally, we will also report on conceptual learning as measured by the FCI and CSEM.

CE02 (1:10 to 1:20 PM MONDAY) Sinugbuanong Binisaya Nga Physics: Culture-Based Material for Physics Learning

Contributed – Presenting Author: Jeovanny Martıcion, San Lorenzo Unified School District

Culture plays a crucial role in the acquisition of knowledge of learners in terms of how motivation shape their Physics learning. The development of culture-based learning materials for Physics was implemented to motivate learners. The learning material utilized the local dialect "Sinugbuanong Binisaya" as a medium of instruction with an integration of local customs and traditions. The material is composed of three (3) major parts – motivation (Ang Pagahisgutan), contents (Mga Termino nga Gigamit) which includes conceptual and procedural concepts in Physics and linking real-life scenarios (Makita sa Palibot). Results revealed significant difference on the dimensions of learning except pressure. Thematic analysis of responses showed unique experiences and culture appreciation. Learners have the opportunity to grasp the concept since there is an easy recall of the concepts as these are already marked within the cultural products.

CE03 (1:20 to 1:30 PM MONDAY) Graphing and Curve Fitting for Introductory Physics

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

Computer-based graphing and analysis of lab experiments at the high school/introductory level can be challenging. Spreadsheet programs are not designed for scientific graphing, while software from equiPM MONDAYent vendors can be costly. In either case, valuable classroom time may be spent learning how to use the tool. nPlot is a free, web-based graphing and analysis program that runs on any platform. It offers a simple user interface that students learn quickly. Features include robust auto-scaling, easy selection among standard fitting models, a curve tangent finder, and error bar plotting. Up to three data sets can be displayed at once to compare different iterations of the same experiment. The graphs produced are professional quality, and can include Greek letters and sub- and super-scripts. The finished plots can be saved on the student's device, or downloaded as an image for inclusion in a lab report.

CE04 (1:30 to 1:40 PM MONDAY) Effect of Selecting Right Coordinates System On Understanding Introductory Courses

Contributed – Presenting Author: Mohammad Alshahrani

Immersing most of educators themselves and their trainers into classic way of teaching and training especially for freshmen's, sophomore who joined into two-year college, and post-secondary institute students. This paper shows how to directly get out of the classical line of teaching either the Newtonian mechanics or Electromagnetic theory efficiently and effectively. This style considers under the best practice techniques. In this paper you will be taken step by step how to prepare the students and transform them starting from their background which is Cartesian coordinate system gradually into the polar coordinates system in order to take them into higher levels. Also, this style could be a cornerstone and would be enhance the way students deal with physics more practical in their workshops, classes and on a daily basis.

CE05 (1:40 to 1:50 PM MONDAY) Using Linear Elasticity to Study the Wave-motion of Flexible Strings

Contributed – Presenting Author: David Argudo, Gavilan College

When deriving the wave equation for a one-dimensional elastic string, introductory physics courses often assume constant tension and/or small amplitude vibrations. However, these simplifying assumptions are not only unnecessary, but they overlook the elastic nature of the tension and yield an inconsistent derivation of the potential energy density. For instance, students often get confused as of how a string can carry elastic potential energy if the underlying assumption is that the tension is constant. In our work, we present a mathematically consistent derivation of the wave equation and potential energy density for the vibrating string. We emphasize throughout the derivations the role of elasticity and we propose a simple experiment where students can use wave theory to predict the elastic properties of strings. We also use our framework to illustrate under which conditions longitudinal waves can be neglected for strings that obey Hooke's law of elasticity.

CE06 (1:50 to 2:00 PM MONDAY) Choosing a Sandbox for Project-based Labs

Contributed – Presenting Author: Nathan Powers, Brigham Young University

Project-based labs provide significant opportunities for students to engage in authentic experimental practices. Over the past several years, we have been shifting from concept-based, verification labs toward project-based labs. Our approach is to choose a sandbox in which students have a strong enough foundation of principles to develop a model but in which there are outstanding questions to be explored. I will discuss our approach to identifying these sandboxes and how we adapt course materials and equiPM MONDAYent to support student exploration.

Session CF: High School

Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Educational Technologies
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** Erick Agrimson

CF01 (1:00 to 1:10 PM MONDAY) Physics & Life

Contributed – Presenting Author: Cherie Bornhorst, Little Shop of Physics, Colorado State University

Science is often taught by discipline—biology, chemistry, physics—but the standards stress the integrated nature of science and the cross-cutting concepts that unify different fields of scientific inquiry. Little Shop of Physics created a kit called "Physics & Life" that uses the tools and concepts of physical science to explore biological systems, unified around the cross-cutting concept "Structure and Function". Students will use light to measure the flow of blood in their bodies, they will use an electrical amplifier to sense the signals from their muscle fibers—and more. There is a lot of physics that underlies the way your body works, and we'll explore 20 different cool experiments that illustrate how principles of electricity, sound, motion, and light are are at work in your body.

CF02 (1:10 to 1:20 PM MONDAY) Searching for Ultra-Short-Period Planets using a Deep Neural Network

Contributed – Presenting Author: Zarar Haider

Additional Author | Jian Ge, Science Talent Training Center

Additional Author | Kevin Willis, Science Talent Training Center

Additional Author | Yinan Zhao, University of Geneva

Ultra-short-period (USP) planets are rare Earth-sized exoplanets with the shortest possible orbital periods of all known planets. To date, only slightly over 100 USPs have been detected, as traditional methods used in detecting USPs are often biased and time-consuming. We introduce a novel GPU fast phase folding technique coupled with a Deep Convolutional Neural Network (DCNN) specifically developed for searching for short period planets. The DCNN was trained on a set of 2,000,000 synthetic USP samples and performs exceedingly well in identifying both true and false positive transit signals, with a 99.5% validation accuracy over the training set and a 100% recovery rate of all existing USPs. Compared to the traditional Box Least Squares method, our method is shown to be ~1000 times faster in searching for transit signals in photometric light curves. This neutral network is being used in searching for additional USPs in Kepler data.

CF03 (1:20 to 1:30 PM MONDAY) Starting the Year with Diversity

Contributed – Presenting Author: James Kernohan, Milton Academy

I will share my experiences with starting the school year with Diversity, Equity, Inclusion, and Justice work. For the first two weeks of my private high school physics classes, both freshmen and seniors, we discussed the lack of diversity in the field of physics and what could be done to combat this. I used materials from underrep.com and others and I will share what I did, some students' reactions, and how I followed up on this throughout the year.

CF04 (1:30 to 1:40 PM MONDAY) Inclusive and Equitable Curriculum and Assignments for Minority Physics Students

Contributed – Presenting Author: Philomena Agu, Jordan Career Center

Most of my students take physics to fulfil state requirements for high school graduation. Their demography calls for curriculum and assignments that are relevant, inclusive, and equitable. Since the majority of the students may not be interested in pursuing careers in the STEM field at colleges and universities, they need to experience everyday physics concepts and contents. Takeaways: Participants will: 1. learn how to shuffle the curriculum to meet the needs of their minority students; 2. use Children's Literature Books to teach resilience and create intentional and relevant physics projects; create culturally relevant, equitable, and inclusive assignments; and 4. assess learning.

CF05 (1:40 to 1:50 PM MONDAY) Physics Teachers Integrating Social Justice with Science Content

Contributed – Presenting Author: Tra Huynh, University of Washington Bothell

Additional Author | Kara E. Gray, Seattle Pacific University

Additional Author | Lauren C. Bauman, University of Washington

Additional Author | Rachel E. Scherr, University of Washington Bothell

Additional Author | Jessica Hernandez, University of Washington Bothell

We study how teachers are integrating social justice in their science lessons. We analyzed lessons submitted by eighteen high school physics teachers who participated in a professional development program that supported the integration of equity into their science teaching. In this talk, we present four themes that represent teachers' approach toward integrating social justice in their science lessons: (1) conducting broad investigations of the nature of physics and underrepresented identity, (2) investigating the nature of science in specific science concepts and re-evaluating/redefining science concepts, (3) connecting students' everyday activities with science and global social justice issues, and (4) using science knowledge to engage with and advocate for social justice issues in students' local communities. These themes showcase the various ways teachers made connections between science content and social justice, pushing the boundary of what is counted as science content by bringing social justice engagement to the center of science learning.

CF06 (1:50 to 2:00 PM MONDAY) Evidence-based Reasoning for Integrated STEM

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

The Next Generation Science Standards call for science teachers to integrate engineering into science instruction. Many teachers address this using integrated STEM units built around engineering design challenges. An important challenge in these units is making sure that students draw meaningful connections between their science learning and the engineering design challenges. In this talk, I will share a framework for evidence-based reasoning, based on the claim-evidence-reasoning framework, that I use to support students in explaining how their engineering design decisions are supported by their science learning. I will also share research on integrated STEM instruction that informed the design of this framework as well as how I apply it in my classroom. When using this framework, I have found students see the engineering design challenges as a meaningful opportunity to apply their science learning.

Session CG: Open Source Physics

Location: CC: Grand Gallery E **Sponsor:** AAPT
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider:** TBA

CG01 (1:00 to 1:10 PM MONDAY) OSP's Hidden Variables

Contributed – Presenting Author: Lyle Barbato, AAPT

Over the past decade, the Open Source Physics project has transitioned from embedded java applets to supporting HTML5/Javascript, EJSS, PWAs, and Tracker. I will give a whirlwind introduction to OSP's hidden projects, their interfaces, and how users can interact with them.

CG02 (1:10 to 1:20 PM MONDAY) Novel Laboratory Activities Emboldened by Open Source Physics

Contributed – Presenting Author: Michael Gallis, Penn State Schuylkill

Introductory Mechanics is rife with opportunities to take students on entertaining excursions off the beaten path. In the author's experience, Open Source Physics tools have been invaluable in taking an offhand observation by student or instructor and escalating it into a real exploration of physical phenomena in what students would see as "real life". In particular, Tracker Video Analysis provides data analysis and modelling opportunities using easy to acquire videos while Easy JavaScript Simulations (EJSS) provides a means to create interactive visualizations which allow introduction of concepts and exploration of the new activity. Some of activities that have been developed within this framework include: work and energy loss in a bungee jump, a "failed" test of gravity (with drag, buoyancy and the Magnus effect), and a visceral implementation of the conical pendulum.

CG03 (1:20 to 1:30 PM MONDAY) Open Source Physics for All Ages

Contributed – Presenting Author: Anne Cox, Eckerd College

Open Source Physics materials are useful in a variety of teaching environments. This talk will examine the types of resources used across the curriculum successfully and how they are structured to help students at each level engage interactively with challenging concepts. We will compare the use of similar simulations with middle school students through upper-level physics majors.

CG04 (1:30 to 1:40 PM MONDAY) WebEJS: A fully Web-based Version of Easy JavaScript Simulations

Contributed – Presenting Author: Francisco Esquembre, Universidad de Murcia, Spain

Additional Author | Félix García Clemente, Universidad de Murcia, Spain

Additional Author | Jesús Chacón, Universidad Complutense de Madrid, Spain

We introduce a new implementation of the successful modeling tool EJS (Easy Java/Javascript Simulations) in its JavaScript variant. WebEJS uses a client-server architecture to help create JavaScript simulations on any Internet-enabled device, without any additional software. The client uses Internet standards, so that it can be run on computers and tablets alike. This WebEJS client stores the user's JavaScript simulations in a user's cloud account, such as Dropbox. The client can also import EJS simulations from the AAPT-ComPADRE digital library.

The WebEJS server provides the power to edit and produce a stand-alone JavaScript simulation in zip format that is independent of EJS. The server is distributed as a Docker container (a fully self-contained package of everything needed), easy to install on standard computer platforms. This client-server combination is a sophisticated but user-friendly use of Internet technologies that results in a platform easy to install and use by teachers and students.

CG05 (1:40 to 1:50 PM MONDAY) Two Different Representations of Complex Number and their Applications

Contributed – Presenting Author: Rolex Rao, future Start & Candle Light

I will add more info. later, now just beat deadline.

CG06 (1:50 to 2:00 PM MONDAY) Using Physics Ideas in Agent-based Modeling of Social Systems

Contributed – Presenting Author: Jan Tobochnik, Kalamazoo College

Additional Author | Harvey Gould, Clark University

Additional Author | Wolfgang Christian, Davidson College

We discuss the modeling of social systems using agent-based models written using the Open Source Physics library. What can be learned from these models? How does physics thinking provide insight into social systems? To illustrate the general approach, we discuss an asset exchange model with variations to show how wealth inequality naturally occurs and how we can obtain a realistic wealth distribution using very few inputs.

CG07 (2:00 to 2:10 PM MONDAY) Incorporating Project-based Learning into Your Physics Courses with OSP

Contributed – Presenting Author: Aaron Titus, High Point University

I loosely define undergraduate research as asking interesting questions and finding answers to those questions. Thus, project-based learning is undergraduate research on a short time scale in the context of a course. Video analysis with Tracker is one of the most economical and flexible experimental techniques to enable students to do independent projects. Computational modeling, using tools such as Easy Java Simulations, allows students to solve problems numerically so they can compare predictions from theoretical models to experimental results. Students' projects will be demonstrated, from introductory to intermediate/advanced levels, with an emphasis on the impact of project-based learning on developing a thriving physics program. If you want to hook students on the excitement of independent discovery, then video analysis and computational modeling are for you.

Session CH: PER: Assessment, Grading and Feedback I

Location: CC: Grand Gallery Overlook F **Sponsor:** Committee on Research in Physics Education
Time: 1–2 p.m. **Date:** Monday, July 11 **Presider: TBA**

CH01 (01:00 to 1:10 PM MONDAY) The Impact of Learning Assistants' PCK-Q on Students' Conceptual Learning

Contributed – Presenting Author: Jianlan Wang, Texas Tech University

Additional Author | Shahin Shawn Kashef, University of Georgia

Additional Author | Beth Thacker, Texas Tech University

Additional Author | Kyle Wipfli, Texas Tech University

Additional Author | Stephanie Hart, Texas Tech 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 investigate how LAs' use of questioning could contribute to students' learning. In this study, we assessed LAs' Pedagogical Content Knowledge regarding Questioning (PCK-Q) with a written instrument describing various situations that LAs would encounter while teaching electromagnetism. We used BEMA and CCTST to measure 80 students' conceptual understanding and critical thinking skills at the beginning and end of an introductory electromagnetism course. With all the data, we built a model to describe the participating LAs' PCK-Q and its impact on students' conceptual learning. We will also introduce our written instrument for the assessment and preparation of LAs' PCK-Q.

CH02 (01:10 to 1:20 PM MONDAY) Who Answers Complex Multiple-choice Questions in Physics Correctly?

Contributed – Presenting Author: Nicholas Young, University of Michigan

Additional Author | Mark Mills, University of Michigan

Additional Author | Rebecca L Matz, University of Michigan

Additional Author | Eric Bell, University of Michigan

Additional Author | Caitlin Hayward, University of Michigan

Complex multiple-choice questions are commonly used to test for physics knowledge, appearing on course exams, concept inventories, and the physics GRE. These questions are assumed to measure more complex thinking than standard multiple choice questions do because students must determine which set of statements is true (e.g., A only, A and C, etc.). Our previous work found students in STEM courses answer these questions incorrectly more often than standard multiple-choice questions. Here, we examine whether there are disparities in who answers these questions correctly in introductory physics compared to other introductory STEM courses. Our data comes from an online, "points-free" test bank where students practice for their upcoming exams using actual questions from previous exams. As expected, results showed significant variation between students in who answers complex multiple-choice questions correctly, which can inform whether using these types of questions might be introducing unintended systematic grade penalties in course exams.

CH03 (1:20 to 1:30 PM MONDAY) Assessing Physics Quantitative Literacy Focused on Conceptualizing Algebraic Ideas

Contributed – Presenting Author: Charlotte Zimmerman, University of Washington

Additional Author | Mieke de Cock, Katholieke Universiteit Leuven

Additional Author | Suzanne White Brahmia, University of Washington

Physics quantitative literacy (PQL) – applying familiar mathematics in novel ways in the context of physics – is ubiquitous across physics classrooms. The Physics Inventory for Quantitative Literacy (PIQL) is a recently published reasoning inventory that can be used to assess PQL from calculus-based introductory physics through upper-division courses (White Brahmia et. al 2021). There remains a need, however, for assessment of PQL at the algebra-based level which includes not only algebra-based college courses but also pre-college physics courses. We present recent work adapting the PIQL to an algebra-based context towards developing the GERQN – the Generalized Equation-based Reasoning inventory for Quantities and Negativity. We report emergent results from our efforts to validate the GERQN with college faculty, high school faculty, and college students, and discuss implications of language accessibility in assessment item development from our experience translating the GERQN into Flemish as part of a larger, on-going research project.

CH04 (1:30 to 1:40 PM MONDAY) Evolution in Student Conceptual Understanding of Energy and Momentum*

Contributed – Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | 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.

CH05 (1:40 to 1:50 PM MONDAY) The Assessment of Introductory-Physics Course by Item Response Theory

Contributed – 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

Additional Author | YUE-LONG XU, 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.

CH06 (1:50 to 2:00 PM MONDAY) Reflective Writing in Physics I

Contributed – Presenting Author: Paige Pressler, Department of Physics, University of North Florida

Presenting Author | Austin Anderson, Department of Physics, University of North Florida

Additional Author | Mark Swartz, Department of Physics, University of North Florida

Additional Author | Kathryn Humphreys, Department of Physics, University of North Florida

Additional Author | W. Brian Lane, Department of Physics, University of North Florida

Learning is a process that involves mutual responsibility (students' relying on others' feedback on their learning) and practice adjustments (changes in a student's approach to a course based on their progress). However, in introductory physics, many students struggle to adjust their practices in response to formative assessments. We studied these difficulties in an introductory physics course by assigning a weekly reflection journal with questions about the students' experience in the course, including the challenges they encountered and the study habits they practiced. We reviewed these students' final reflection assignment and recorded themes that emerged: These students talked about collaboration, course difficulty, responsibility, self-managed growth, and a lack of change in academic success or practices. These insights into the student learning experience will be used to generate course improvements.

LILLIAN MCDERMOTT MEDAL: Wolfgang Christian

The Promise and Impact of Computation for Teaching

Wolfgang Christian

People have dreamed of and built machines to automate computation starting with the abacus in 3000 BC, the Mechanical Calculator of Leonardo da Vinci, the Arithmetic Machine of Blaise Pascal, the punch cards of Joseph-Marie Jacquard, the Calculating Engines of Charles Babbage, and the Automatic Computing Engine of Alan Turing. After World War II, computational power advanced rapidly through the invention of transistors, integrated circuits, microprocessors, and countless other devices until the pocket computers of today. But the use of computers for instruction was an afterthought. The first use of computers for Computer Added Instruction (CAI) is attributed to Donald Bitze who developed the Programmed Logic for Automatic Teaching Operations (PLATO) system in the 1960s at the University of Illinois at Urbana-Champaign. However, CAI did not become practical or widespread until the introduction of the personal computer and the release of the World Wide Web by CERN in 1993.

Few would have predicted how the combination of at-your-fingertip computation and the internet would change the world, including teaching practice. But has the computer become just a magic box, a modern Zauberkasten, made of wires and integrated circuits that lets physics teachers do magic tricks, such as simulating molecular dynamics, the time evolution of quantum wavefunctions, or the collision of black holes? Do computers foster interactive engagement, or do they inhibit creative thinking, human interaction, and attention spans? Have computers fundamentally improved how we teach and learn physics?

This talk presents a personal history of how computers and the internet have challenged me and changed how I teach. I present examples to show that computers can provide a learning experience that utilizes students cognitive, affective, and psychomotor domains of learning.

AAPT PHYSICS EDUCATION

Monday, July 11

2:30–3:30 p.m.

Hotel:

Ambassador

Ballroom

Session DA: "I Teach Physics and..."

Location: CC: Grand Gallery A **Sponsor:** Committee on Physics in High Schools
Time: 3:30–4:40 p.m. **Date:** Monday, July 11 **Presider:** Dan Crowe

This session is for teachers to give insight on their courses that they teach outside of a traditional physics sequence. For example courses like environmental science, chemistry, biology, etc.

Session DB: Life Beyond Physics

Location: CC: Grand Gallery B **Sponsor:** Committee on the Interests of Senior Physicists
Time: 3:30–4:40 p.m. **Date:** Monday, July 11 **Presider:** Randall Knight

What do retired physicists do with their time? And does thinking like a physicist help with other activities? Five "retired" but still very active physicists will discuss what life is like beyond a physics-teaching career.

Session DC: Modern Eddington Experiment 2024

Location: CC: Grand Gallery C **Sponsor:** Committee on Space Science and Astronomy
Time: 3:30–4:40 p.m. **Date:** Monday, July 11 **Presider:** William Dittrich

The Modern Eddington Experiment was successfully performed during the 2017 total eclipse by Portland Community College (PCC) students in Oregon under the guidance of Richard Berry at his Alpaca Farm Observatory. The second successful attempt in 2017 was performed by Don Bruns in Wyoming, and his success was the most accurate Eddington Experiment ever performed yielding the Einstein Coefficient of 1.75 exactly with an error of 3%. Now, PCC's Toby Dittrich is organizing an attempt in Mexico during the upcoming April 2024 eclipse which will potentially gather thousands of data points instead of the usual tens of data points. With the potential of having as many as twelve telescope stations, each gathering images of 1000 stars, the 2024 experiment could become one of its own in the front of the list of historic Eddington Experiments. Now, there is plenty of time for you to join in this effort to involve your students in the measurement of the curvature of space. This Topical Session will discuss what is needed in terms of equiPM MONDAYent and procedures, so that our world class experts Richard Berry and Don Bruns can assist us in this execution of the Modern Eddington Experiment. PCC now has acquired four telescopic stations for use and there is room at the fabulous site in Mexico, exactly on centerline at the point of maximum eclipse, for eight more stations. I hope you can join in this exciting and historic effort to promote the use of the Eddington Experiment in the Advanced Lab curriculum at many colleges/universities in the future.

Session DD: PER: Diversity, Equity & Inclusion I

Location: CC: Grand Gallery E **Sponsor:** Committee on Research in Physics Education
Time: 3:30–4:40 p.m. **Date:** Monday, July 11 **Presider:** TBA

DD01 (3:40 to 3:50 PM MONDAY) Where Women of Color Earn Physics Degrees: Fact and Fiction

Contributed – Presenting Author: Jessica Changstrom, Kansas State University

Katelynn Hubbenig, Kansas State University

Additional Author | Angela C Johnson, St. Mary's College of Maryland

Additional Author | Apriel Hodari, Eureka Scientific

Additional Author | Eleanor C Sayre, Kansas State University

We elicited common narratives about where women of color earn bachelor's degrees in physics, and compared those narratives to 12 years of IPEDS data, encompassing XXXXX physics graduates at YYYY institutions nationwide. We looked for shared characteristics among institutions where women of color tend to earn physics degrees, such as geographic location & setting, institutional size & mission, and fraction of people of color at the institution (among other characteristics). Physics departments in minority-serving institutions and women's colleges tend to graduate proportionally more women of color, even after controlling for institutional racial and gender demographics, than predominantly white co-educational institutions. Other common narratives related to institution size, location, and Carnegie classification are not supported by the data. To help participants understand the landscape, we introduce an online tool for faculty, departments, and prospective students to compare among institutions.

DD02 (3:50 to 4:00 PM MONDAY) Exclusionary Fields or Departments?: Undergraduate Degrees for Women of Color

Contributed – Presenting Author: Katelynn Hubenig, Kansas State University

Additional Author | Jessica R Changstrom, Kansas State University

Additional Author | Angela C Johnson, St. Mary's College of Maryland

Additional Author | Apriel Hodari, Eureka Scientific

Additional Author | Eleanor C Sayre, Kansas State University

Women of Color have been historically excluded from STEM fields, particularly in physics, mathematics, and computer science. How do these fields compare on a departmental level? We looked for correlations among the fraction of degrees earned by women of color in physics, math, and computer science among 1500 US institutions of higher learning using IPEDS data from 2008 to 2020. After normalizing for institutional racial and gender demographics, we sought correlational institutional characteristics (e.g. size, location, Carnegie classification, etc) to determine whether departmental practices or institutional characteristics were more likely to exclude women of color from these degrees. In this talk we discuss both institutional characteristics and intra-institutional inter-field correlations to suggest that all three disciplines are separately and especially bad at graduating women of color, even above and beyond their institutional racial and gender demographics.

DD03 (4:00 to 4:10 PM MONDAY) Investigating Experiences of Women in Color in Physics and Astronomy

Contributed – 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.

DD04 (4:10 to 4:20 PM MONDAY) Gender Bias in Peer Recognition Across Course Levels and Contexts

Contributed – Presenting Author: Meagan Sundstrom, Cornell University

Additional Author | Ashley B. Heim, Cornell University

Additional Author | Barum Park, Cornell University

Additional Author | N. G. Holmes, Cornell University

Recognition from others, including peers, is a critical component of students' science identities. Gender stereotypes, however, may influence who gets recognized. Previous research has found a gender bias in students' nominations of knowledgeable peers in introductory biology and physics courses, but not in a mechanical engineering course serving beyond-first-year students. In this study, we collected and analyzed student nominations of knowledgeable peers in three physics courses, separating recognition in laboratory (lab) and non-lab instructional contexts. Results suggest that whether or not a gender bias is present in non-lab perceptions depends on student population: courses serving first-year students exhibit a gender bias, while those at the beyond-first-year level do not. We also generally find no gender bias in lab recognition, suggesting that perceptions of peers form differently in these two contexts. We will discuss these results and their implications for teaching.

DD05 (4:20 to 4:30 PM MONDAY) Women Have Lower Physics Self-efficacy Controlling for Grade

Contributed – Presenting Author: Sonja Cwik, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Self-efficacy has been shown to affect student engagement, learning, and persistence in science, technology, engineering, and math (STEM) courses and majors. Additionally, prior research has shown that women have lower self-efficacy than men in STEM courses in which women are outnumbered by men. This study examines the self-efficacy of men and women with similar performance in two consecutive algebra-based introductory physics courses in which women make up two thirds of the students. These were mandatory courses at a large public university in the US taken primarily by bioscience majors, many of whom are interested in health professions. Our findings show a gender gap in self-efficacy disadvantaging women when controlling for course grades in both physics 1 and physics 2 both at the beginning and end of the course. Additionally, we find that most of the gender gap in self-efficacy is due to biased perceptions rather than performance in the courses.

DD06 (4:30 to 4:40 PM MONDAY) Analysis of Free Supplemental Resources Impact on Diverse Student Body

Contributed – Presenting Author: Dawson Nodurft, Texas A&M University

Students enter introductory physics courses with a diverse range of backgrounds and experiences. Some are college ready, others are well ahead, and some need more help. To help all students succeed, we have created free supplemental materials aimed at helping different types of learners that include videos and practice exam bank. We will present the analysis of the impact of these supplemental materials on student outcomes in the introductory calculus-based electricity & magnetism class. In addition, we will compare these materials' impact on different demographics of students. We will discuss how we tracked student usage of these materials directly through the website. In addition, we will share student feedback on the utility and impact of the supplemental materials.

Session DE: PER: Student and Instructor Support & Professional Development, Program and Institutional Change I

Location: CC: Grand Gallery Overlook G **Sponsor:** Committee on Research in Physics Education
Time: 3:30–4:40 p.m. **Date:** Monday, July 11 **Presider: TBA**

DE01 (3:40 to 3:50 PM MONDAY) Personas for Supporting Physicists' Engagement in Informal Education

Contributed – Presenting Author: Shams El-Adawy, Kansas State University/American Physical Society

Additional Author | Alexandra C Lau, American Physical Society

Additional Author | Eleanor C. Sayre, Kansas State University

Additional Author | Claudia Fracchiolla, American Physical Society

The pathways and engagement of physicists in informal physics education are varied, which makes their professional development needs not well understood. As part of ongoing efforts to build and support community in the informal physics space, we conducted interviews with physics practitioners and researchers with a range of different experiences. Through thematic analysis, we use personas methodology to articulate the needs and pain points of professional physicists. We present our set of four personas: the physicist who wants to get started in informal physics, the physicist who wants to increase the value of informal physics, the public engagement professional who wants to expand their network, and the faculty member who wants to find ways to sustain engagement in informal physics among their many responsibilities. This work will allow APS to create tailored resources for the variety of professional development needs of practitioners and researchers engaged in informal physics.

DE02 (3:50 to 4:00 PM MONDAY) Does Social Justice from the Top Trickle Down?

Contributed – Presenting Author: Michael Fox, Department of Physics, Imperial College London

Additional Author | Camille Kandiko Howson, Centre for Higher Education Research and Scholarship, Imperial College London

Additional Author | Martyn Kingsbury, Centre for Higher Education Research and Scholarship, Imperial College London

We analyse an institutional curriculum change initiative from the perspective of academics in a physics department in the United Kingdom to identify the barriers faced when curriculum change is used as a process to increase equity, diversity, and inclusion (EDI). We explore what curriculum means in physics, how power relationships within the university affect the response to top-down change, and ultimately who has control over the curriculum. We find that the different conceptulisations of curriculum in physics compared to educational research means that a directed top-down approach stalls when concepts that fall outside of the physics curriculum, such as EDI, are introduced. Nevertheless, initiatives that are in response to EDI concerns that would be considered to be curriculum change from an educational research perspective are enacted within the department on a localised scale.

DE03 (4:00 to 4:10 PM MONDAY) How Can PERers Support Emerging Community Members' Self-efficacy?

Contributed – Presenting Author: Christopher Hass, Kansas State University

Additional Author | Emilie Hancock, Central Washington University

Additional Author | Shams El-Adawy, Kansas State University

Additional Author | Samantha Wilson

Additional Author | Scott V. Franklin, Rochester Institute of Technology

DBER attracts many faculty from STEM disciplines, yet these faculty have limited specific training in DBER. DBER's inherent interdisciplinarity is particularly challenging for emerging DBER researchers who often get started in DBER with only discipline-specific content and research training. As part of a study about how STEM faculty become involved with DBER, we interviewed emerging DBER faculty about their pathways into DBER. We conducted a thematic analysis of these interviews focusing on self-efficacy following the work of Bandura. Our analysis identified 3 roles for emerging and experienced DBER researchers that support the self efficacy of new faculty entering DBER. These roles are the "peer," the "subject matter expert," and the "project manager." We call on the PER community to take up these roles in support of new and emerging members.

DE04 (4:10 to 4:20 PM MONDAY) Characteristics of Departments with High-use of Active Learning*

Contributed – Presenting Author: Charles Henderson, Charles Henderson

Additional Author | Alexandra Lau, American Physical Society

Additional Author | Melissa Dancy, Western Michigan University

Additional Author | Marilyne Stains, University of Virginia

Additional Author | Christian Merino, Western Michigan University

In 2019, sampling by institution, we conducted a web-based survey of 3,769 instructors who taught introductory chemistry, mathematics, and physics. Some departments had multiple instructors who made high use of active learning instructional strategies. We conducted interviews with 27 instructors in 16 such departments. Using grounded theory methods, we developed a model that highlights the relevant characteristics of departments that have high use of active learning instruction in their introductory courses. According to this model, there are four main characteristics of such departments (motivated people, knowledge about teaching, opportunities, and cultures and structures that support active learning) and two positive feedback loops. There are two main take-away messages for those interested in promoting the use of active learning. The first is that all four components are important. The second is that desired outcomes are obtained and strengthened over time through the two positive feedback loops.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE 2028134 (M.S.), 1726328 (C.H.), and 1726042 (M.D.). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

DE05 (4:20 to 4:30 PM MONDAY) Supporting Pre-Service Teachers in Building Upon Student Ideas in Instruction

Contributed – Presenting Author: Michael Hull, University of Vienna

Additional Author | Haruko Uematsu, Tokyo Gakugei University

Additional Author | Andrew Elby, University of Maryland

At the University of Vienna and Tokyo Gakugei University, we aim to impress upon our pre-service teachers (PSTs) that student ideas are not always robustly intact and inherently incorrect cognitive structures, but rather that student ideas can be (and often are) more accurately described as a temporary coherence of smaller knowledge pieces that can productively be drawn upon in instruction. To this end, we use Open Source Tutorials (OSTs) to introduce the "Pieces" model (in contrast to the "Misconceptions" model) of student ideas. In our courses, PSTs read research literature about OSTs, conduct mock lessons using existing OSTs, design their own OSTs, use their own OSTs with highschool students, and reflect upon the process to improve their OSTs. We will draw upon data from in-class observations, one-on-one interviews, and written coursework to discuss how PSTs came to recognize that effective instruction can build upon student ideas.

DE06 (4:30 to 4:40 PM MONDAY) Undergraduates Develop their Imagined Future Professional Selves

Contributed – Presenting Author: Hien Khong, Kansas State University

Additional Author | Brandi Lohman , Kansas State University

Additional Author | Eleanor C. Sayre , Kansas State University

How do undergraduate students imagine their future professional lives after graduation? We conducted longitudinal semi-structured interviews with undergraduate students about their career goals and resources needed to develop professional identities using future possible self theory. We present multiple case studies of physics students exploring, adjusting, and refining their possible future selves. Overall, participants had elaborated future possible selves that were influenced by both academic and sociocultural experiences. High self-efficacy and positive interactions in the field positively impact students' imagined futures, whereas low self-efficacy and low recognition sabotage students' future possible selves; these ideas intersect with students' personality, lifestyle, and social identity. In this talk, we'll share two ways in which students refine their future possible selves: a path of narrowing and refining imagined futures; and a path of trying new selves in series.

Session DF: Physics Education Research in the K-12 Classroom, Physics Majors: High School to Doctorate
Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Physics in High Schools
Time: 3:30–4:30 p.m. **Date:** Monday, July 11 **Presider:** Dan Crowe

DF01 (3:40 to 3:50 PM MONDAY) Integrating Computation in the Algebra-based High School Physics Classroom

Contributed – Presenting Author: Terrie Galanti, University of North Florida

Additional Author | Adam P. Mantovani, Duval County Public Schools

Additional Author | Forouzan Faridian, Santa Monica College

Additional Author | W. Brian Lane, University of North Florida

Additional Author | Julia Whitley, University of North Florida

Computation has rapidly become an invaluable facet of STEM education and readiness for STEM professions. Developing a computational mindset and skill base requires sustained learning experiences across the STEM subjects, ideally beginning in high school and continuing through higher education. Physics is one such STEM subject where computation can deepen conceptual understandings and develop application-oriented computational competencies. However, many high school physics teachers have little experience with research-validated pedagogical uses of computation, and physics education literature has a limited array of readily deployable computational activities that are appropriate for high school students. We present our facilitation of a computation-oriented online professional development for in-service physics teachers. We focused on content learning experiences for teachers with the goal of collaboratively adapting module activities for their classrooms. We illustrate the outcomes of this professional development by sharing the reflections of one participant teacher who is implementing materials in a general physics course.

DF02 (3:50 to 4:00 PM MONDAY) Aspects of Classical Education Movement In Physics Education Research Literature

Contributed – Presenting Author: Paul Hosmer, Hillsdale College

The classical education movement addresses physics, as it does with many other fields, in ways that are sometimes similar, but sometimes unique—or at least uncommon—as compared to the way physics is addressed outside the movement. These differences extend to all aspects of physics education, from motivation, to focus, to content, to pedagogy, and more. Are these often-unique aspects of physics education as handled in the classical education movement addressed, either directly or indirectly, in the physics education research literature? If so, how do they stand up? This talk explores what physics education research literature might say about physics in the classical education movement.

DF03 (4:00 to 4:10 PM MONDAY) Exploring Factors Influencing the Retention of Physics Majors

Contributed – Presenting Author: John Stewart, West Virginia University

Additional Author | John Hansen, West Virginia University

Additional Author | Eric Burkholder, Auburn University

This talk examines the retention of physics majors at a two moderately sized physics departments which struggle with increasing the number of graduates. The two institutions have undergraduate populations with substantially different levels of high school preparation. Survival analysis identifies the point of highest risk for two potential paths out of the major: leaving college and changing majors. Substantial risk of losing majors exists through the first two years of college. The results for changing major while staying in college were very different between the two institutions. Logistic regression is used to explore the factors related to retention in general and through the first two years of college. At the less selective institution, math readiness is a crucial factor predicting retention.

DF04 (4:10 to 4:20 PM MONDAY) Alumni Engagement in Undergraduate Physics and Astronomy Departments

Contributed – Presenting Author: Andrew Zeidell, American Institute of Physics

Physics and astronomy departments generate alumni every year, and we often ask for ways to keep in touch with them. Alumni can be an invaluable resource for high school and undergraduate students navigating their academic and postgraduate careers by acting as a point of contact, giving talks, or helping run outreach events. This talk discusses ways to create a departmental legacy of physics and astronomy alumni and how to engage your alumni to strengthen your outreach, engage with students, and provide invaluable knowledge and network connections to students about to graduate.

Session DG: Supporting Physics Teaching with a Planetarium

Location: Planetarium in Exhibit Hall **Sponsor:** Committee on Space Science and Astronomy
Time: 3:30–4:30 p.m. **Date:** Monday, July 11 **Presider:** Richard Gelderman

DG01 (3:40 to 3:50 PM MONDAY) Getting to Mars – Applied Astrodynamics Visualized

Contributed – Presenting Author: Richard Gelderman, Western Kentucky University

Orbital calculations are a major player in the story of Andy Weir's "The Martian." The crew originally gets from Earth to Mars by firing rockets to convert a circular orbit around Earth into an elliptical orbit around the Sun which intersects the orbit of Mars. A planetarium allows us to picture how this path makes sense. It is also easy to see why "a straight line is the shortest distance between two points" is not going to be a viable axiom to travel between worlds. This brief visualization could stand alone for a general population of learners, or be combined with mathematical-based arguments in higher level courses.

DG02 (3:50 to 4:00 PM MONDAY) Seeing the Whole Picture: Practical Uses for the Electromagnetic Spectrum

Contributed – Presenting Author: Diane Yoder, Digitalis Education Solutions and The Boonshoft Museum of Discovery

The electromagnetic spectrum is a vital part of understanding the world around us and sure to be an important component of your classroom. Start your students off right by using the gateway science of astronomy to motivate and inspire them. A trip to the planetarium will immerse viewers in awe-inspiring imagery, while simultaneously sharing practical uses for each wavelength of radiation. This "whole picture" view will prepare students for the rigors of the classroom in the lectures to come. From microwaves in your kitchen, to the cosmic microwave background, the planetarium allows physics teachers to share a new perspective on a core topic.

DG03 (4:00 to 4:10 PM MONDAY) Student's Choice Awards:Preliminary Results of a Survey on Planetarium Impact

Contributed – Presenting Author: Jannette Lawler

Session DH: Upper Division Undergraduate

Location: CC: Grand Gallery Overlook A/B **Sponsor:** AAPT
Time: 3:30–4:30 p.m. **Date:** Monday, July 11 **Presider:** TBA

DH01 (3:40 to 3:50 PM MONDAY) Mie Optical Scattering as an Analog to Nuclear Scattering

Contributed – Presenting Author: Frederick Becchetti, University of Michigan

Additional Author | Ramon Torres-Isea, University of Michigan

Without access to a cyclotron or similar nuclear particle accelerator, it is difficult for students to measure and study nuclear scattering at energies above the Coulomb barrier. While Rutherford scattering can be done in an undergraduate laboratory, the alpha-particle energies from a typical radioactive source are too low to be sensitive to nuclear-potential scattering and hence as a measure of nuclear dimensions. We will show that Mie optical scattering from micro-spheres suspended in liquids and utilizing a complex index of refraction can reproduce quite well nuclear scattering of neutrons and protons from nuclei at bombarding energies above the Coulomb barrier. This provides a good analog for the "optical model" of nuclear scattering. The latter is valid provided the ratio of incident wavelength to the size of the scattering object (λ/D) is appropriate. As will be shown, this also applies to similar scattering processes over a wide range of dimensions.

DH02 (3:50 to 4:00 PM MONDAY) Social Network Analysis of Student Collaboration in Pandemic-affected Courses

Contributed – Presenting Author: Nate Crossette, University of Colorado Boulder

Additional Author | Lincoln D Carr, Colorado School of Mines

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Social network analysis (SNA) has been gaining traction as a technique for quantitatively studying student collaboration. We analyze networks in two courses from the University of Colorado Boulder and one course from the Colorado School of Mines. All three courses occurred during the COVID-19 pandemic, which allows for a comparison between courses in a variety of formats (i.e., in-person, remote, or hybrid). We compute nodal centrality measures and calculate the correlation between student centrality and performance. Results varied widely between each of the courses studied which suggests that the context and environment in which the course is situated has an important effect on the link between student collaboration and performance. Additionally, we investigated the effect of missing nodes on the correlations we measured, which showed that missing nodes tend to shift correlations towards zero, suggesting that the statistically significant correlations measured in our networks are not spurious.

DH03 (4:00 to 4:10 PM MONDAY) Simulating Quantum Dynamics with IBM Quantum Computers

Contributed – Presenting Author: Jarrett Lancaster, High Point University

Additional Author | Daniel B. Allen, High Point University

We demonstrate how freely-available, cloud-based, IBM quantum hardware can be used to perform several types of quantum dynamics simulations. Though current devices are far from capable of tackling truly difficult problems which cannot be attacked classically, these noisy, intermediate-scale quantum (NISQ) devices are ideally suited for investigating quantum dynamics in small systems. Simulations of one or two spins with fairly arbitrary interactions and external fields are shown to agree well with theory, but even a system consisting of three spins is shown to be quite difficult to simulate due to noise and errors. These investigations are shown to be well-suited as a computational and experimental supplement to the standard undergraduate quantum mechanics curriculum.

DH06 (4:20 to 4:30 PM MONDAY) Impact of Pre-class Reading and Peer Instruction in Quantum Mechanics

Contributed – Presenting Author: Ryan Sayer, Bemidji State University

Additional Author | Emily Marshman, Community College of Allegheny County

Additional Author | Chandralekha Singh, University of Pittsburgh

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 feedback. We investigate the effectiveness of a JiTT approach, which included in-class concept tests using clickers, in an upper-division quantum mechanics course. We analyze student performance on pre-lecture reading quizzes and in-class clicker questions answered individually and then again after group discussion and compare those performances with open-ended retention quizzes administered after completing instruction on the concepts. In general, compared to the reading quizzes, student performance improved when individual clicker questions were posed after lectures that focused on students' identified difficulties. The performance on the clicker questions after group discussions following individual clicker question responses also improved, as did the performance on retention quizzes administered at a later time. We discuss some possible reasons for the improved performance at various stages of instruction.

Milestones and Attitudinal and Motivational Factors in Physics Graduate Students

Contributed – Presenting Author: Christopher Porter, The Ohio State University

Additional Author | Sara Mueller, Brown University

Additional Author | Andrew F Heckler, The Ohio State University

For five years, researchers at OSU have been collecting attitudinal and motivational data from physics graduate students at several universities across the Midwest. The data collected pertain to factors associated with retention at the undergraduate level in STEM, most of which have not previously be studied at the graduate level. These factors include sense of belonging, physics identity, and self-efficacy, among others. Information on milestones toward a Ph. D. has also been collected, including information on publications, talks, and departmental requirements such as qualifying exams. In this talk, we will focus on correlations between different factors, and correlations between these factors and milestone achievement. We also present an exploratory factor analysis showing that these many attitudinal and motivational factors load onto two composite factors (with eigenvalues greater than 1.0). An initial, rough interpretation of these factors will be discussed.

Formally Organized Graduate Student Study Groups: Let's Talk About That

Contributed – Presenting Author: Brandon James Johnson, University of Maryland - College Park

In the Spring semester of 2022, I, a sixth-year physics graduate student, helped organize and conduct several small study groups for first-year physics graduate students. The purpose of these groups was to help students in their graduate course work and encourage peer-to-peer collaborative working relationships. In this talk I will introduce the implementation of these study groups and open up the space for questions.

Session DI: Supporting Faculty and Students in the Era of COVID

Location: CC: Grand Gallery Overlook F **Sponsor:** Committee on Women in Physics
Time: 3:30–4:30 p.m. **Date:** Monday, July 11 **Presider:** Anne Cox

DI01 (3:40 to 4:10 PM MONDAY) Using Mutual Mentoring to Mitigate Isolation for TYC Physics Faculty

Invited – Presenting Author: Kristine Lui

A feeling of isolation can contribute to leaks in the pipeline. Being "the only one" certainly leads to a sense of isolation, whether as a woman, as a racial minority, or as the sole physics instructor in the institution. Sixty percent of two-year colleges (TYCs) that offer physics classes have no or one full-time physics instructor (aip.org/statistics). Isolation is a critical issue for physics faculty at TYCs, and for both full-time and part-time instructors. This is even more critical in the era of COVID. Isolation for TYC physics faculty may be mitigated by creating virtual-meeting mentorship groups. In this presentation, I will share the development and implementation of a pilot project for TYC physics faculty, adapted from the e-Alliance mutual mentorship program for women in physics. I wish to thank the e-Alliance Leadership Team for their support on this project, as well as Lyle Barbato for his work on the technical side of creating the TYC Mentorship interface.

DI02 (4:10 to 4:40 PM MONDAY) Faculty Members' Experiences During the COVID-19 Pandemic

Invited – Presenting Author: Courtney Walsh, AIP

Since the beginning of the COVID-19 pandemic, faculty members have faced a changed and challenging environment. They were faced with reallocating their time across various teaching, research, and service responsibilities; adjusting their teaching format, testing, and labs; and dealing with reduced access to the resources they needed to teach and/or conduct research, all while trying to maintain the quality of their work and personal well-being. Using data from the American Institute of Physics' Statistical Research Center 2021 Faculty Member Survey, we will dissect some of these changes and discuss how they may (or many not) vary based on faculty members' gender identity and parenting status.

DI (4:40 to 5:10 PM MONDAY) Supporting Students in Current Times of Change

Invited – Presenting Author: Rachel Ivie, American Institute of Physics

Additional Author | Brad R Conrad, Society of Physics Students @ AIP

Without a doubt, students have been affected by COVID-19, the changes it brought to classroom instruction, and its effects on so many aspects of life. However, COVID is not the only outside force that is altering the college experience for students. In addition to the effects of COVID, this talk will discuss trends in the US population and in higher education and how they may affect students. We also will present data from an AIP survey of the effects of COVID on undergraduate physics and astronomy majors. Based on these data, we will present recommendations for ways faculty members and departments can support students during these times of change.

POSTER SESSION I:
Location: CC: Exhibit Hall C **Sponsor:** AAPT
Time: 7–8:30 p.m. **Date:** Monday, July 11

NOTE: Persons with odd-numbered posters will present their posters from 7:00 to 7:45 p.m.; those with even-numbered posters will present from 7:45 to 8:30 p.m. Posters will be available until 10 p.m.

Astronomy

POS1A01 (7:00 to 7:45 PM MONDAY) Dark Energy Explorers: Using Citizen Science to Enhance the Hobby-Eberly-Telescope-Dark-Energy-Experiment

Poster – Presenting Author: Lindsay House, University of Texas at Austin

Additional Author | Keely Finkelstein, University of Texas at Austin

Additional Author | Karl Gebhardt, University of Texas at Austin

We present a citizen science campaign, Dark Energy Explorers, aiming to improve the Hobby-Eberly Telescope Dark Energy Experiment (HETDEX). HETDEX will collect at least one million galaxies that are 9 - 11 billion light-years away, yielding one of the largest maps of the universe. We created Dark Energy Explorers on Zooniverse, the world's largest citizen science platform to help us classify these astronomical objects. With Dark Energy Explorers we train participants, of any background, to be able to distinguish different galaxies by swiping left or right on their smartphone. Initial analysis has shown that citizen science is an efficient and effective tool for classification most accurately done by the human eye. Since launching in late February 2021, we have reached 3.5 million classifications by 8,000 volunteers in 80 countries! Dark Energy Explorers has proven to be a uniquely powerful tool for science advancement and increasing accessibility to science worldwide.

POS1A02 (9:45 to 10:30 PM MONDAY) Carbon Dioxide and Astronomy I: Hands on Laboratory*

Poster – Presenting Author: Yeaton Clifton

Climate in a broad sense, is subject for astronomy when discussing planets with atmospheres. Basic principles of science that are used in a range of astronomy topics. The laboratories presented include a) a demonstration of Wein's law (why certain wavelengths are emitted by the earths surface). b) Demonstration of a standard carbon detector (the scattering of infrared light by carbon dioxide is so well established that is used to measure levels of carbons dioxide). The poster will explain how both low cost laboratories can be developed and how the information can be used to understand the temperature of range of worlds with atmospheres. The exercise also includes anti-greenhouse gases on titan and how they form in that atmosphere.

* I have a PhD in physics from East Carolina University and a PhD in education from Oakland University but I do not currently have an institution.

POS1A03 (9:00 to 9:45 PM MONDAY) Carbon Dioxide Hands On Experience 2: Chemical Reasoning

Poster – Presenting Author: Yeaton Clifton Clifton

Climate in a broad sense, is subject for astronomy when discussing planets with atmospheres. Basic principles of science that are used in a range of astronomy topics. The connection between fossil fuels, carbon dioxide and the ocean becoming more acidic can be less than clear, even when the data showing that carbon dioxide has been increasing for the past 2 centuries. This paper describes the use of organic chemistry kits to understand how planetary atmospheres are shaped. The poster will describe exercises using basic chemistry kits that illustrate burning hydrocarbons creating carbon dioxide as a product and the merging of carbon dioxide and water to create carbonic acid. The poster will also discuss the creation chemicals in Titan's atmosphere that have anti-greenhouse effects.

POS1A04 (9:45 to 10:30 PM MONDAY) Discovering Solar Flares with High School Students

Poster – Presenting Author: Nicole Gugliucci, Saint Anselm College

Additional Author | Carl Zent, Saint Anselm College

Additional Author | Seth Adams, Saint Anselm College

The radio sky is accessible at low cost with the RadioJOVE Project, a dual-dipole with receiver that is used by educators, students, and amateur radio astronomers to detect solar flares and radio bursts from Jupiter. In 2019, a short course on radio astronomy was designed by four undergraduates at Saint Anselm College as part of Access Academy, an afterschool program for immigrant, refugee, and underrepresented high school students in Manchester, New Hampshire, through the Meelia Center for Community Engagement. The project has been revived with a new undergraduate instructor for Access Academy and the course developed to go beyond construction of the telescope to data analysis. We will provide an update on the Saint Anselm RadioJOVE featuring new solar flare detections made by high school students and plans to incorporate RadioJOVE 2.0, a spectrograph that will facilitate more sophisticated science.

POS1A05 (9:00 to 9:45 PM MONDAY) Augmented Reality, Spatial Reasoning, and the Teaching of Lunar phases

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

Additional Author | George Hassel, Siena College

Additional Author | Michele McColgan, Siena College

For students to gain a true mastery and understanding of lunar phases, they must also develop the necessary spatial reasoning skills. These skills include 1) The ability to change perspectives between an Earth-centered Solar System model and a horizon view of the observed sky at the same time; and 2) The ability to transfer between 2-D and 3-D representations of the Earth, Moon, Sun system. Augmented Reality, AR, provides a unique opportunity for students to both visualize, explore, and manipulate 3-D observations in both the solar system representation and the horizon representation, as well as forcing students to observe both in 3-D and 2-D representations at the same time. For this project, several successful activities previously developed by R. Lindell based were adapted to include AR visualizations and manipulations to better teach the concept of Lunar Phases. To participate in the pilot testing of these activities, please contact TiliadalSTEM@gmail.com.

Labs/Apparatus

POS1B01 (7:00 to 7:45 PM MONDAY) Graphing Energy Efficiency in Introductory Physics Labs

Poster – Presenting Author: Andrew Pawl, University of Wisconsin-Platteville

Linearizing data and extracting information from linear regression are skills that are commonly taught as part of the laboratory curriculum in introductory physics. In this presentation I describe how I have adapted a series of standard experiments ranging across several topics in introductory mechanics and electricity to involve plotting input energy as an independent variable and output energy as a dependent variable. In each case, this analysis yields a linear graph with slope equal to the efficiency of the energy transfer in the experiment. This shifts the goal of these experiments away from using the linear regression to confirm a predicted value and instead asks students to use the regression to determine an unknown parameter. This approach also allows the students to compare the relative efficiency of various methods of converting stored energy as they progress through the courses.

POS1B02 (7:45 to 8:30 PM MONDAY) Radiant Cooling in the Student Lab and Beyond

Poster – Presenting Author: Sam Sampere, Syracuse University

Additional Author | Eric A. Schiff, Syracuse University

Radiant cooling and heating of objects is a commonplace of life on earth. We have developed a student laboratory that explores radiant cooling, infrared thermometers, and the applications of the Stefan-Boltzmann equation. Beyond the many everyday applications, we designed the laboratory to scaffold student understanding of the atmosphere's effect on the earth's surface temperature. The experiments use widely available apparatus: a handheld infrared thermometer, a small radiant heating panel, and an electrical power monitor. The first experiment familiarizes the student with the infrared thermometer and its use around a building and outside. The second experiment explores aluminized Mylar as an infrared mirror. The third experiment explores how application of the Mylar film modifies the cooling of the heat panel by blocking its infrared emission. Algebra-based physics students finished the lab in two hours and got reasonable agreement with the Stefan-Boltzmann prediction.

POS1B03 (7:00 to 7:45 PM MONDAY) Exoplanet Research: Student Experimentation in High School

Poster – Presenting Author: Dorottya Schnider, ELTE

Presenting Author | Mihály Hömöstrei, ELTE

Exoplanets and exoplanet research? An attractive topic, not only for high school students. The topic of planets outside the Solar System is not covered in the Hungarian Physics textbooks, however, the methods of exoplanet research in connection with some Physics matura exam tasks have already appeared in secondary school Physics education. No wonder, since exoplanet research is one of the successful, modern, and evolving areas of astronomy today, let's deal with it in Physics! The aim of our poster is to present an Arduino-based classroom experiment in the topic of exoplanet-research, which develops competences and support students with appropriate techniques in classical modeling of the transit method of exoplanet research. Our method supports teachers in designing lesson plans based on the learning outcomes.

POS1B04 (7:45 TO 8:30 PM MONDAY) Simple Home-built Laboratory Experiments for Remote Learning

Poster – Presenting Author: Keith Madden, Ivy Tech Community College

Until recently, COVID-19 had forced most traditional colleges to switch from in-person physics labs to labs based on computer simulations and video analysis. At two-year colleges, online physics classes are a large fraction of the physics courses, with laboratory equipment requirements satisfied by commercial lab kits. These are expensive and of little use after the course ends. Building their labs at home with household materials created a less expensive, more engaging laboratory experience for our distance education students. Our students used prescription pill vials, braided fishing line, U.S. coins (as calibrated masses), rulers, and, of course, paper clips to build their experiments. Initially students were given detailed building instructions but more leeway with each succeeding experiment. The students showed ingenuity in building their experiments and enhanced course engagement. We will present examples of these experiments in this poster.

POS1B05 (7:00 TO 7:45 PM MONDAY) Smart Physics: Bouncing from the Board to the Screen**

Poster – Presenting Author: Jake Postiglione, New York City College of Technology CUNY*

Additional Author | Juan Sebastian Poveda Correa, New York City College of Technology CUNY

Additional Author | Giovanni Ossola, New York City College of Technology CUNY

As our society continues to venture into a newfound age of technology, educators must continuously adapt to the ever-changing lens through which students learn. Due to the Covid-19 pandemic the need for such a paradigm shift has been made abundantly clear. The Smart Physics project aims to provide educators and students new ways of investigating the physical world through common sensors built into almost every smart device. These investigations can be performed in both traditional classroom settings and in asynchronous online courses. We analyze the way in which our team has gone from "board to screen" and follow the process of developing an investigation that can be conducted by students in introductory physics courses. Specifically, we look at the development of an investigation measuring the time intervals between the bounces of an object using an acoustic stopwatch in order to measure the energy lost through a series of inelastic collisions.

*The poster provides more details on topics which are part of a Contributed Talk presented by Giovanni Ossola (which is the AAPT member sponsoring this poster presentation).

**The activities presented are developed as part of a collaboration between the University of Padova(1) and the New York City College of Technology of CUNY (2), which included Elisa BERNARDINI (1), Marta CARLI (1), Mohamed Yousry ELKHASHAB (1), Andrea FERROGLIA (2), Miguel FIOLHAIS (3), Lucia GABELLI (1), Henrik JESSEN MUNCH (1), Darya KRYM (2), Pierpaolo MASTROLIA (1), Giovanni OSSOLA (2), Ornella PANTANO (1), Jake POSTIGLIONE* (2), Juan Sebastian POVEDA CORREA (2), Chiara SIRIGNANO (1), Francesca SORAMEL (1).

POS1B06 (7:45 to 8:30 PM MONDAY) Smart Physics: Flexible and Customizable Physics Experiences**

Poster – Presenting Author: Juan Sebastian Poveda Correa, New York City College of Technology CUNY*

Additional Author | Giovanni Ossola, New York City College of Technology CUNY

Additional Author | Jake Postiglione, New York City College of Technology CUNY

Not all general physics courses are the same. Some of them are directed to non-STEM majors, some to pre-med students. More commonly they serve a variety of science students that have different skills in mathematics (i.e., algebra- vs calculus-based courses). While designing new laboratory experiences, adaptability and flex-

ibility are key aspects to consider. Smart Physics, a collaboration between CUNY and the University of Padova, Italy, gave us an opportunity to explore the use of the phyphox application in our laboratory experiences, thus exploiting the sensors and the technology that is already incorporated into most cellular phones. Running different experiments to test the functionalities of the app, we saw that, thanks to its different formats and variations, it is possible to create activities and adapt them to meet different educational goals. Moreover, with minimal adaptations, they provide the additional flexibility to do labs online, by requiring very limited remote resources.

The poster, presented by an undergraduate student, provides more details on topics which are part of a Contributed Talk presented by Giovanni Ossola (which is the AAPT member sponsoring this poster presentation).

**The activities presented are developed as part of a collaboration between the University of Padova(1) and CUNY (2), which included: Elisa BERNARDINI (1), Marta CARLI (1), Mohamed Yousry ELKHASHAB (1), Andrea FERROGLIA (2), Miguel FIOLHAIS (2), Lucia GABELLI (1), Henrik JESSEN MUNCH (1), Darya KRYM (2), Pierpaolo MASTROLIA (1), Giovanni OSSOLA (2), Ornella PANTANO (1), Jake POSTIGLIONE (2), Juan Sebastian POVEDA CORREA* (2), Chiara SIRIGNANO (1), Francesca SORAMEL (1).

Lecture/Classroom

POS1C01 (7:00 to 7:45 PM MONDAY) COVID-Related Introductory Exam Questions and Analysis

Poster – Presenting Author: Dan Young, University of North Carolina at Chapel Hill

Additional Author | Colin Wallace, University of North Carolina at Chapel Hill

Additional Author | Duane Deardorff, University of North Carolina at Chapel Hill

The COVID-19 pandemic caused colleges and universities to make difficult and drastic shifts with respect to instruction methods. However, one of the advantages of the pandemic was the ability to provide students with current, real-world examples that are based on concepts that are developed during instruction at the introductory level. At the University of North Carolina, Chapel Hill, we have devised several exam problems that are directly related to COVID-19 and test concepts such as diffusion, electric dipole moments, and representing data on logarithmic axes. On this poster, we will discuss the questions we asked along with sample student responses and will provide guidance for instructors who wish to modify and use the questions within their own classrooms.

POS1C02 (7:45 to 8:45 PM MONDAY) Lessons Learned from Embedded Research Course at a Community College

Poster – Presenting Author: Laura Wood, Michigan State University

Additional Author | John Byrd, Michigan State University

Additional Author | Ronald J. Stamper, Mott Community College

Additional Author | Robert Dudock, Mott Community College

Additional Author | Charles Wade, Mott Community College

Collaboratively, we studied a project-based research methods course called STEM-199 at Mott Community College, taking observational fieldnotes, soliciting weekly student journal reflections, and interviewing students. In collaboration with the instructors, we identified themes across those data sources. The main theme we found was the prevalence and impact of instructor support for their students, emotionally, logistically, and technically. This support helped students develop a sense of resilience in the face of research difficulties in a class that was highly student-driven with students having high project ownership. We share lessons learned from the course to provide guidelines for other teachers, particularly at two-year colleges (TYCs). We focus on characterizing the key components of STEM-199 that helped the course run successfully at the TYC and could help a similar course work at other institutions; including: high teacher-student ratio; and student-driven projects with restrictions to limit the scope of instructor work.

POS1C03 (7:00 to 7:45 PM MONDAY) Engaging Students in Energy Learning by Practicing Community Decision Making

Poster – Presenting Author: Victoria Augustine, Berkeley High School, Berkeley, California

Additional Author | Rachel E Scherr, University of Washington Bothell

Additional Author | Jessica B Hernandez, University of Washington Bothell

Electric energy production and use affects every person in the USA, and teaching energy in high school physics should enable students to participate in public decision making about energy resources. In a large high school in a major metropolitan area, the "City of Berkland" project empowers students to be able to participate in future decisions about power production and use. After instruction in energy and electricity, the citizens of the (fictional) City of Berkland call a City Council meeting to discuss the possibility of a nuclear power plant in the city. "Residents" of the City of Berkland and surrounding areas argue for or against nuclear power in their city from the point of view of their position in the city and its environs. The project is highly engaging for students and supports them to connect their learning about electricity and energy to decisions that matter in their community.

POS1C04 (7:45 to 8:30 PM MONDAY) Reorganization of Physics Curriculum with a Focus on Student Growth

Poster – Presenting Author: Joseph Martinez, California State University, San Bernardino

We investigated a new approach to physics curriculum focusing on student growth using interleaved practice. While the current physics curriculum focuses on the mastery of a single topic in a short time, we reorganized our curriculum to interleave several topics starting with basic conceptual questions and gradually increase the difficulty of problems students face throughout the semester. With early feedback from students taking a second-semester calculus-based physics class, we can show that the restructuring of the course has led students to become more confident in their problem-solving abilities and are more capable of long-term retention of material.

POS1C05 (7:00 to 7:45 PM MONDAY) A Multi-Course Integration of Computation into Our Physics Curriculum

Poster –Presenting Author: Michael Massa, University of Guelph

Additional Author | Matthew Steffler, University of Guelph

Additional Author | Danielle St. Jean, University of Guelph

Additional Author | Melanie Hudakoc, University of Guelph

Additional Author | Martin Williams, University of Guelph

Like many other physics departments in recent years, we have worked to integrate computational activities into our physics curriculum.

Our integration has focused on second-year physics courses, where we have adopted a centralized approach: The computational strand is interwoven through multiple courses and is administered independently of the course instructors. Our goal has been to provide regular, cohesive exposure of computation, contextualized to their courses, without overburdening any one course/instructor. We will present the structure of the computation exercises and their evolution, the coding assessment & feedback tool that we have developed, as well as student growth and reflections over the past four years.

POS1C06 (7:45 to 8:30 PM MONDAY) Using 3 Dimensional Learning to Improve Student Learning on Assessments

Poster – Presenting Author: Paul Begeron, Michigan State University

Additional Author | James T. Laverty, Kansas State University

Three-Dimensional Learning (3DL) is a framework that provides tools to help highlight what we want our students to be able to do with their knowledge. This framework creates opportunities for students to learn physics in sways authentic to the practice of science by aligning course content along 3 Dimensions: Scientific Practices that encompass what scientists do to explore phenomena, Core Ideas that underpin our discipline's central concepts, and Crosscutting Concepts that provide the lenses for how we view phenomena. Research into 3DL has shown that implementing the framework provides substantial benefits to student learning, but does take effort. With this poster, I will discuss how to use the 3 Dimensional Learning Assessment Protocol as a tool for creating 3DL-aligned assessment items. I will share strategies to transforming existing problems and how to create 3D items from scratch, and where our data best suggests effort is most efficiently put.

POS1C07 (7:00 to 7:45 PM MONDAY) Applying the Tactile Reaction Training TReaT in a Physics Classroom

Poster – Presenting Author: Thommy Boehlig, Wing Tsjun international

Additional Author | Sascha Therolf, University of Cologne

Additional Author | André Bresges, University of Cologne

How might we use breaks in physics classes to provide a meaningful experience, heighten cooperation and concentration, and provide more safety for kids on the way to school?nWe developed a Tactile Reaction Training that we call TReaT and can be embedded in physics classes without compromises to lab safety. The training is about ten minutes for each of them and focused on getting a better body feeling to react more appropriately in danger situations. Aspects of Germany's core curriculum in Physics, e.g. conservation of Momentum, Force and Motion is connected to the training. We tested the approach with 38 students of fifth and sixth grade over six weeks. For evaluation, we arrayed 10 students in a line across a marked lined that should resemble a train or bus stop. The kids who participated in TRT were significantly more often able to withstand the push and kept a safe stand.

POS1C08 (7:45 to 8:30 PM MONDAY) (Naïve) Aerodynamic Concepts in-class & in-game – Flight Physics Concept Inventory

Poster – Presenting Author: Kathleen Falconer, Institute of Physics Didactics, University of Cologne, Germany

Additional Author | Florian Genz, Future Strategy for Teacher Education, University of Cologne, Germany

Additional Author | André Bresges, Institute of Physics Didactics, University of Cologne, Germany

We have developed a gamified lecture & a tool for automatic evaluation of (naïve) concepts in flight physics for online and paper-pencil use: The Flight Physics Concept Inventory (FliP-CoIn) (1). We present a gamified lecture for eliciting, confronting and resolving naïve concepts collaboratively. Used as pre-test, FliP-CoIn informs teachers about initial pre, naive, alternative or misconceptions of the students entering a class. Used as pre/post assessment, FliP-CoIn can inform faculty and funding personnel on effectiveness of certain methods. The distractors are based on naïve student concepts; the correct answers on expert opinions. We have optimized the instrument's validity and internal reliability (alpha>=0.80). We present example data and questions for comparing student data and interpreting the results. Beyond, we sketch a gamified lesson for overcoming naïve concepts collaboratively with the help of the newly developed Flight Physics Concept Inventory.
(1) https://www.physport.org/assessments/assessment.cfm?&A=FliPCoIn

POS1C09 (7:00 to 7:45 PM MONDAY) Physics for the Modern World

Poster – Presenting Author: Donald Franklin, retired, consult for Openstax.college

Designed for Pre Med Physics classes. The ebook available from Openstax,college is free to download. It uses only human objectives to teach the Physics needed in their Medical Major. It starts with Optics and covers all the topics except for Inclined Planes and Levers.

POS1C10 (7:45 to 8:30 PM MONDAY) A Streamlined Approach to the Introductory Physics Textbook

Poster – Presenting Author: Sam Hill, Adrian College

Most introductory physics textbooks combine theory, applications, problem-solving, and history in a single volume, resulting in a hefty (and often expensive) tome. The result is often tedious for students to read, and it can be difficult for students to know which portions of the reading they are responsible for and to what extent; and if students do not read the textbook, it is difficult to devote class time to problem-solving and groupwork. I am writing a free, online textbook which focuses strictly on the theory and equations underlying introductory physics, with a focus on readability. The book is shorter than usual, with each page devoted to a specific topic to allow reading in short blocks, and students have reported preferring it over the standard physics textbook. It will be available for beta testing this fall for those who might be interested in using it for their own classes.

General Topics

POS1D01 (7:00 to 7:45 PM MONDAY) Hands-on Gauss' Law Activity in Introductory Electricity and Magnetism

Poster – Presenting Author: Belter Ordaz Mendoza, University of Connecticut

Additional Author | James Jaconetta, University of Connecticut

Gauss' law is an important learning goal in introductory electricity and magnetism undergraduate course. Gaussian surfaces and symmetries are essential concepts of Gauss' law that students find abstract and therefore hinder their conceptual understanding of it and their ability to solve problems. We develop a hands-on activity based on 3D printed objects with different symmetries to give students a hands-on learning experience of Gauss' law in a Studio classroom.

POS1D02 (7:45 to 8:30 PM MONDAY) STEM MILES: Mentoring Innovative Learning Experiences for Students

Poster – 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 in the fourth year 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. This work was supported by NSF DUE-1742635 and by Santa Rosa Junior College.

POS1D03 (7:00 to 7:45 PM MONDAY) A Case Study: Gender Differences in Higher Education Courses

Poster – Presenting Author: Camila Amaral, University of Utah

Additional Author | Larissa Inácio, Universidade Federal do Rio de Janeiro

Additional Author | Daniela Szilard, Universidade Federal do Rio de Janeiro

Additional Author | Midiã Souza, Universidade Federal do Rio de Janeiro

Additional Author | Marta Barroso, Universidade Federal do Rio de Janeiro

Gender inequities in science and technology courses in higher education has been subject to studies in several countries, but most part of these researches are conducted in North American and European institutions. In this paper we present a case study from an university in South America, analyzing data available in the institution's academic management systems and in public data publicized by the Ministry of Education. We found that, despite the difference of performance in the Natural Sciences component of the access exam that grant access to higher education, the number of freshmen by sex in exact sciences courses is not very different. However, in graduate courses, this difference is significant, revealing another aspect of the "scissors effect". A consolidation of all these kind of information is compelling, to clearly scale the situation, raise testable hypotheses about its motives, and evaluate possible intervention to reduce gender inequalities.

POS1D04 (7:45 to 8:30 PM MONDAY) The Low-cost Student Project on "Acoustic Tweezer"

Poster – Presenting Author: Yuehai Yang

In this poster, the authors will present a low-cost undergraduate student-led project on acoustic levitation, a.k.a., "acoustic tweezer", by using ultrasound waves to lock small objects in air. Students in this project will develop in-depth understanding and skills in using physical models that we commonly introduced in our general physics courses to solve real-world problems in engineering and biomedical fields. Schlieren imaging is also used to visulize the principle behind the levitation. This project can also be used as a demo or an observational experiement for students to learn about stand waves and sound.

POS1D05 (7:00 to 7:45 PM MONDAY) Outline of a Workshop about Having Interactions Regarding Climate Misinformation

Poster – Presenting Author: Zachary Pruett, American Physical Society

Additional Author | Alexandra Lau , American Physical Society

Presenting Author | Claudia Fracchiolla , American Physical Society

Additional Author | Callie Pruett, American Physical Society

This talk presents the outline of a pilot, 4-week, virtual workshop about having more productive interactions regarding climate change misinformation. Misinformation surrounding the scientific process, scientific findings, and scientists negatively affects global security, public health, public discourse, and scientific funding. The goal of the workshop, delivered to members of The American Physical Society, was to empower the participants with a community, tools, and concepts that can help them be more effective in addressing climate change misinformation. Topics included: a logical fallacy categorization tool known as FLICC (Fake experts, Logical fallacies, Impossible expectations, Cherry picking, and Conspiracy theories), the fact-myth-fallacy-fact rebuttal format, an understanding of the importance of personal identity in decision making, and a tool for engaging in conversations known as reflective listening. Workshop time was split between small-group conversations about suggested activities, slides presenting new information, and practice time for implementing new concepts within small-groups.

POS1D06 (7:45 to 8:30 PM MONDAY) Impact of Summer Research in a Small Liberal Arts Setting*

Poster – Presenting Author: Toni Sauncy, Texas Lutheran University Department of Physics

Additional Author | Jennifer Mata, Texas Lutheran University Center for Mexican American Studies

Additional Author | Kevin Tate, Texas Lutheran University Department of Biology

A collaborative NSF-funded grant project between the departments of Biology, Mathematics, Physics, and Psychology, along with the Texas Lutheran University (TLU) Center for Mexican American Studies provides support for an 8-week faculty-mentored student research program. The summer research program is one component of the overall project, which is focused on building culturally informed teaching and mentoring among faculty and embracing cultural intersections among students to understand what interventional strategies are effective in bridging STEM identity with individual cultural identity. The ultimate goal of the work is to improve student retention and success in STEM fields, particularly for groups which have been marginalized. Results of surveys an focus groups, as well as feedback from faculty mentors from the first cohort in the Summer of 2021 with preliminary findings on impact will be discussed.

*This work is supported by NSF IUSE:HSI Award No. 1953561.

POS1D07 (7:00 to 7:45 PM MONDAY) Utility of Differential Models in Algebra-Based Physics

Poster – Presenting Author: Joshua Rutberg, Rutgers University - Newark

Most introductory algebra-based physics courses focus entirely on simple situations for which neat analytical solutions exist: constant acceleration, freefall, simple harmonic motion. One of the main reasons for this is that most of our students lack the mathematical tools to investigate these complicated situations which more closely match those they would find in the real world. However, the use of spreadsheets and coding languages enables a different but powerful approach to situations whose analytical solutions are too difficult for algebra-based students to deal with. When using differential models, students can observe complex behavior emerge from simple, easily-understood rules. Here we demonstrate a number of situations from mechanics and circuits which highlight the advantage of differential models in making complex phenomena accessible to students with little background in math such as motion with non-uniform acceleration, air resistance and terminal velocity, simple and damped harmonic motion, non-Ohmic resistance, and RC circuits.

Physics Education Research I

POS1E01 (7:00 to 7:45 PM MONDAY) What Supports the Trajectories of White Men in Physics?

Poster – Presenting Author: Danny Doucette

In the field of physics, there is an overrepresentation of white men. This suggests that careers in physics are not equally accessible to all people. Excellent scholarship has identified barriers and biases that make it challenging for women, for people of color, and especially for women of color to persist and succeed in physics. I am interested in addressing the other side of the coin: what structures in the culture and practice of physics may provide extra advantages for white men who seek to become physicists? The constructs of whiteness and masculinity provide a framework that may help answer this question. I will share some initial results based on a series of interviews with early-career white male physicists.

POS1E02 (7:45 to 8:30 PM MONDAY) Social Network Analysis of Student Collaboration in Pandemic Affected Courses

Poster – Presenting Author: Nate Crossette, University of Colorado Boulder

Additional Author | Lincoln D Carr, Colorado School of Mines

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Social network analysis (SNA) has been gaining traction as a technique for quantitatively studying student collaboration. We analyze networks in two courses from the University of Colorado Boulder and one course from the Colorado School of Mines. All three courses occurred during the COVID-19 pandemic, which allows for a comparison between courses in a variety of formats (i.e., in-person, remote, or hybrid). We compute nodal centrality measures and calculate the correlation between student centrality and performance. Results varied widely between each of the courses studied which suggests that the context and environment in which the course is situated has an important effect on the link between student collaboration and performance. Additionally, we investigated the effect of missing nodes on the correlations we measured, which showed that missing nodes tend to shift correlations towards zero, suggesting that the statistically significant correlations measured in our networks are not spurious.

POS1E03 (7:00 to 7:45 PM MONDAY) Socio-Metacognitive Experiences in a Course for Future Teachers

Poster – Presenting Author: Jayson Nissen, Nissen Education Research and Design

Additional Author | Thanh Lê, Western Washington University

Additional Author | Carolina Alvarado, California State University - Chico

Additional Author | Andrew Boudreaux, Western Washington University

Research-based instructional materials often use an elicit - confront - resolve strategy to guide students toward formal science concepts. Eliciting and confronting contradictions between formal and every-day physics concepts often causes confusion. Students can resolve their confusion through socio-metacognition, which involves planning, monitoring, and regulating each other's ideas and optimizing their collaboration. While confusion can lead to deeper learning and understanding, confusion can also lead to frustration and disengagement. The research investigates socio-metacognition by building mixed-methods, case-studies of students and groups using multiple data sources: self-reported emotional experiences during the activity, written reflections, classroom video, and interviews. We will overview the collective students' experiences of the course. Then, we will explore the lesson with the most mathematics content, where students had the highest confusion and stress, using a case study of a student's experience during class and their self-advocacy during and after class.

POS1E04 (7:45 to 8:30 PM MONDAY) Undergraduates Develop their Imagined Future Professional Selves

Poster – Presenting Author: Hien Khong, Kansas State University

Additional Author | Brandi Lohman, Kansas State University

Additional Author | Eleanor C. Sayre, Kansas State University

How do undergraduate students imagine their future professional lives after graduation? We conducted longitudinal semi-structured interviews with undergraduate students about their career goals and resources needed to develop professional identities using future possible self theory. We present multiple case studies of physics students exploring, adjusting, and refining their possible future selves. Overall, participants had elaborated future possible selves that were influenced by both academic and sociocultural experiences. High self-efficacy and positive interactions in the field positively impact students' imagined futures, whereas low self-efficacy and low recognition sabotage students' future possible selves; these ideas intersect with students' personality, lifestyle, and social identity. In this poster, we'll share two ways in which students refine their future possible selves: a path of narrowing and refining imagined futures; and a path of trying new selves in series.

POS1E05 (7:00 to 7:45 PM MONDAY) Who Answers Complex Multiple-choice Questions in Physics Correctly?

Poster –Presenting Author: Nicholas Young, University of Michigan

Additional Author | Mark Mills, University of Michigan

Additional Author | Rebecca L. Matz, University of Michigan

Additional Author | Eric Bell, University of Michigan

Additional Author | Caitlin Hayward, University of Michigan

Complex multiple-choice questions are commonly used to test for physics knowledge, appearing on course exams, concept inventories, and the physics GRE. These questions are assumed to measure more complex thinking than standard multiple choice questions do because students must determine which set of statements is true (e.g., A only, A and C, etc.). Our previous work found students in STEM courses answer these questions incorrectly more often than standard multiple-choice questions. Here, we examine whether there are disparities in who answers these questions correctly in introductory physics compared to other introductory STEM courses. Our data comes from an online, "points-free" test bank where students practice for their upcoming exams using actual questions from previous exams. As expected, results showed significant variation between students in who answers complex multiple-choice questions correctly, which can inform whether using these types of questions might be introducing unintended systematic grade penalties in course exams.

POS1E06 (7:45 to 8:30 PM MONDAY) Comparison of Expert-like Attitudes and Scientific Reasoning Skills

Poster – Presenting Author: Amber Sammons, South Fork Jr./Sr. High School

Additional Author | Rebecca Rosenblatt, National Science Foundation EHR/HRD

Additional Author | Raymond Zich, Illinois State University

Results from a multi-semester study of the effects of eight supplemental laboratory activities in a general education physics will be presented. A total of two control and three treatment semesters were studied. The results allowed comparison between expert-like attitudes measured by the CLASS and scientific reasoning skills measured by the Lawson CTSR. Comparison of the pre/posttest CLASS scores and posttest Lawson CTSR scores found no correlation between the overall scores or the scores from the question groups measuring specific attitudes or reasoning skills. Additionally, both student attitudes and scientific reasoning skills showed improvement for the first semester the intervention was applied. In subsequent semesters, improved scientific reasoning skills continued to be observed while improvement in students' scientific attitude faded. A detailed comparison of the CLASS and CTSR scores will be presented along with a discussion of the implications for instruction given this apparent decoupling of expert-like attitudes and reasoning skills.

POS01E08 (7:45 to 8:30 PM MONDAY) Understanding the Impact of the Drew Science Scholars Program*

Poster – Presenting Author: Hady Omar, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Nationally, there have been a number of programs that are designed to better support students from historically underrepresented racial and ethnic communities and economically disadvantaged students (NASE&M, 2016). Yet, the underrepresentation continues. Education researchers have turned to ask questions about which programs work, why they work, and who they best work for (Estrada, Eppig, Flores, 2019). The Charles Drew Science Scholars is one such program. The Drew program produces results and our research supports the documentation of these results. With an increased GPA, graduation rate, and academic success, the Drew program is doing something right. In this presentation, we will outline the core elements of the Drew Scholars program and describe the outcomes on student success, particularly for students from historically underrepresented communities. We will also outline the implications of this work for future work to support STEM students.

*Vashti Sawtelle - Sponsoring this presentation

POS1E09 (7:00 to 7:45 PM MONDAY) Revolutionary Love Help Students Navigate Belonging to a Science Community?

Poster – Presenting Author: Camila Monsalve, Physics and Astronomy, Michigan State University

Creating a sense of belonging requires a constant negotiation process for an individual. For students, with one or more marginalized identities, this process is particularly fraught when we consider the social aspects of learning during the transitioning from a community or across STEM fields. In this poster we will draw from the work of scholars who have explored this negotiation process for science learners (e.g. Hyater-Adams, Ong, Secules, and Marco-Bujosa.) We will explore different perspectives of the tensions navigated as students who identify as Black, African American, Latina and/or as a woman negotiate belonging in science. We then explore how Valarie Kaur's Revolutionary Love framework explains folks' experiences of belonging in a university after transferring from a community college or across STEM fields.

POS1E10 (7:45 to 8:30 PM MONDAY) Investigating Measures of Self-Efficacy Disaggregated by Time

Poster – Presenting Author: Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

In this poster we examine what constitutes high, normal and low self-efficacy - or the confidence in one's capability to perform a task - for one student. We draw from a study where we used a novel mixed methods design to examine how a student's self-efficacy fluctuates over time. Quantitatively, we employed the Experience Sampling Method (ESM) using surveys of domain-specific self-efficacy. Qualitatively, we used daily journal reflections to investigate threats and supports toward students' self-efficacy. In order to identify high, normal, and low moments of self-efficacy we have explored their individual interquartile range. Here, we will present our mixed-methods analysis to examine how disaggregating by time influences the process of identifying how, normal, and low self-efficacy.

POS1E11 (7:00 to 7:45 PM MONDAY) How Societal Issues Impact Instructors' Views of DEI

Poster – Presenting Author: Christian Merino, Western Michigan University

Additional Author | Charles Henderson, Western Michigan University

Additional Author | Mellissa H Dancy, Dancy Consulting

Additional Author | Marilyne Stains, University of Virginia

Additional Author | Naneh Apkarian, Arizona State University

Instructors' views of diversity, equity, and inclusion (DEI) are important for shaping their instructional practices as well as how they interact with DEI initiatives. Events in 2020, such as COVID and Black Lives Matter, have placed an increasing emphasis on DEI issues nationally. As part of a larger study, we conducted a web-based survey to understand how these societal issues have impacted instructors' views of DEI. We received 1,065 responses from STEM instructors teaching introductory courses. Approximately half of respondents indicated that their views of DEI had changed during 2020. In this talk, we will discuss open-ended explanations that instructors gave for how and why their views of DEI changed or did not change. Implications for improving equity in undergraduate instruction will be discussed.

POS1E12 (7:45 to 8:30 PM MONDAY) Evolution in Student Conceptual Understanding of Electricity and Magnetism

Poster – Presenting Author: Mary Brundage, University of Pittsburgh - Pittsburgh, PA

Additional Author | Chandralekha Singh, University of Pittsburgh - Pittsburgh, PA

The Conceptual Survey of Electricity and Magnetism (CSEM) is a multiple-choice survey that contains a variety of electricity and magnetism concepts at the level of introductory physics used to help inform instructors of student mastery of those concepts. Prior studies suggest that many concepts on the survey are challenging for introductory physics students and the average student scores after traditional instruction are low. The research presented here compares the performance of students in introductory, upper-level, and graduate-level physics courses on five CSEM questions to understand the cross-sectional evolution of student understanding of these concepts from the introductory to upper-level to graduate-level. We discuss five CSEM questions that remain challenging for many upper-level and graduate students.

POS1E13 (7:00 to 7:45 PM MONDAY) Gravity

Poster – Presenting Author: akambaraswaran akambaraswaran

All planets are rotating with surrounding sun.by the effect of rotation the speed energy will exists.that energy makes pressure and spreading inside the surface of the planet and its garbing all those things is called gravity force.see in you tube akambaraswaran

POS1E14 (7:45 to 8:30 PM MONDAY) Evolution in Student Conceptual Understanding of Energy and Momentum*

Poster – Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | 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.

POS1E15 (7:00 to 7:45 PM MONDAY) Learning Environment Predicts Women's Motivational Beliefs in Introductory Physics Courses

Poster – Presenting Author: Sonja Cwik, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

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.

POS1E16 (7:45 to 8:30 PM MONDAY) Self-efficacy, Perceived Recognition, Interest and Identity of Physics Majors*

Poster – Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Kyle Whitcomb, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Motivational characteristics in physics have been increasingly recognized recently, with prior studies establishing a framework for students' physics identity being composed of perceived recognition by instructors and peers, along with physics self-efficacy and interest. We extend this research beyond introductory physics students by using five years of cross-sectional data collected from motivational surveys administered to physics majors throughout their undergraduate education and to the first-year physics PhD students at a large research university in the US. We find that the responses of physics majors over time from their first year of undergraduate through first year PhD remain largely consistent. Also, consistent with prior studies with introductory students, we find that perceived recognition is the best predictor of physics identity for physics majors throughout their entire education, pointing to the importance of physics instructors making a concerted effort to constantly recognize their students throughout as people who can excel in physics. *Work supported by NSF

POS1E17 (7:00 to 7:45 PM MONDAY) Using Clicker Question Sequence to Teach Time-Development in Quantum Mechanics

Poster – 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.

POS1E18 (7:45 to 8:30 PM MONDAY) Students' Types of Interest in Physics

Poster – Presenting Author: Sarah Zoechling, CERN & University of Vienna

Additional Author | Martin Hopf, University of Vienna

Additional Author | Julia Woithe, CERN

Additional Author | Sascha Schmeling, CERN

Given the central importance of increasing high school students' interest as a goal of physics education in international science standards, empirical support for the theoretical description of interest is essential. Previous studies about students' interest in physics focused on gender issues and did not include modern physics contents. Thus, we investigate which aspects of physics students are interested in and whether they can be categorised into different interest types based on their interest profiles and physics-related self-concept. We conducted a cross-cohort study with German-speaking students aged 14 to 16 years (N = 1214). A mixed Rasch analysis revealed that most students are interested in physics only when set in a context related to one's own body, socio-scientific issues, and existential questions of humankind. Knowing high school students' types of interest will enable educators to better design their learning activities and increase their students' interest.

POS1E19 (7:00 to 7:45 PM MONDAY) How Do New Physics Faculty Teach? New Faculty Workshop Insights*

Poster – Presenting Author: Stephanie Chasteen, Chasteen Educational Consulting

Additional Author | Rajendra Chattergoon, Lexia Learning

We investigate teaching attitudes and practices using surveys of N=442 participants in the Physics and Astronomy New Faculty Workshop (NFW).* Most participants are aware of published teaching approaches, and value and want to use student-centered instruction (SCI). Some have experienced SCI as a student or TA. They are not confident of their ability to enact SCI, however, showing that self-efficacy is an important faculty learning target. Our results suggest a continued shift in norms in the physics community, such that most new physics faculty enter the professoriate needing minimal encouragement to try SCI. We do find, however, that about 20%, most often at PhD-granting institutions, are not as open to student-centered instruction. We recommend that professional developers support faculty as agentic learners engaged in a process of lifelong learning by helping them develop self-efficacy, agency, and metacognition.

*This material is based upon work supported by NSF-1431638, and published in 10.1103/PhysRevPhysEducRes.16.020164.

POS1E20 (7:45 to 8:30 PM MONDAY) Female Students' Self-efficacy Benefits Most from Same-gender Group Work

Poster – Presenting Author: Alysa Malespina, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

We investigate the effect of working in mixed or same-gender groups on physics self-efficacy and self-reported ''peer influence on self-efficacy" in a calculus-based introductory physics course in which women are severely underrepresented. We found that men had higher physics self-efficacy and reported higher peer influence on self-efficacy than women, likely due to societal stereotypes and biases. All students except those who worked in same-gender groups had a decrease in average physics self-efficacy from the beginning to the end of the semester. Finally, gender predicted self-efficacy for students who worked in mixed-gender groups, but not for those in same-gender groups. Our findings suggest that instructors should implement classroom policies that encourage equitable and inclusive group work, so that all students can thrive.

POS1E21 (7:00 to 7:45 PM MONDAY) Does Test Anxiety Explain Gender Differences in Physics Exam Scores?

Poster – Presenting Author: Alysa Malespina,

Additional Author | Chandralekha Singh, University of Pittsburgh

In this work, we used survey data and grade information to compare the predictive power of self-reported self-efficacy and test anxiety on low-stakes (e.g., homework and quizzes) and high-stakes (e.g., traditional exams) assessment scores in a traditionally taught large introductory physics course. We found that there are gender differences in both self-efficacy and test anxiety, as well as in high-stakes assessment outcomes. There were no gender differences in low-stakes assessment scores. Further, we found that models that control for self-efficacy and/or test anxiety eliminate the predictive power of gender for high-stakes assessment scores. Finally, we found that self-efficacy partially mediates the effect of test anxiety on high-stakes assessment outcomes. These trends suggest that teaching methods that alleviate test anxiety have the potential to create a more equitable learning environment.

POS1E22 (7:45 to 8:30 PM MONDAY) New Theory of Earth Gravity

Poster – Presenting Author: akambaraswaran m, nill

In universe all planets are just rotating according to its quantum and speed.In earth Mr. Issac newton has understood from the fallen of apple earth has gravity. finally he published a formula is related with sun and earth.But I am an astrology researcher has researched and discovered WHEN EVER A PLANET ROTATES WITH THE QUANTUM OF SPEED BY THAT EFFECT THE PRESSURE OF FORCE WILL EXIST.THAT PRESSURE OF FORCE IS KNOWN AS GRAVITY.It all happens in our sun planet family.so the equation is G=Rotation of Planet / Pressure.(G=RP/P) my presentation about gravity watch you tube https://youtu.be/k1ekXMAcEAU

POS1E23 (7:00 to 7:45 PM MONDAY) A Skateboarding Experiential Learning Activity for Introductory Physics

Poster – Presenting Author: Liang Zeng, The University of Texas-Rio Grande Valley

Presenting Author | Guang Zeng, Texas A&M University-Corpus Christi

Additional Author | Oscar Guerrero , IDEA Public Schools

Additional Author | George Garcia , The University of Texas-Rio Grande Valley

Instructors teaching introductory college physics courses are in a unique position to explain physics in skateboarding and associated potential risks. An instructor taking students to a skate park to measure the impact forces can enhance student understanding of physics in skateboarding, analytical thinking skills, and appreciation of physics in everyday life. Students can discuss their skateboarding experiences and learn preventative measures to avoid injuries.

POS1E24 (7:45 to 8:30 PM MONDAY) How Inclusiveness of Learning Environment Predicts Students' Physics Motivational Beliefs

Poster – Presenting Author: Yangqiuting Li, University of Pittsburgh

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.

POS1E25 (7:00 to 7:45 PM MONDAY) Development Clicker Questions on Addition of Angular Momentum in QM

Poster – Presenting Author: Paul Justice, University of Cincinnati

Additional Author | Emily Marshman, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

Engaging students with well-designed clicker questions is one of the commonly used research-based instructional strategy in physics courses partly because it has a relatively low barrier to implementation. Moreover, validated robust sequences of clicker questions are likely to provide better scaffolding support and guidance to help students build a good knowledge structure of physics than an individual clicker question on a particular topic. Here we discuss the development, validation and in-class implementation of a clicker question sequence (CQS) for helping advanced undergraduate students learn about addition of angular momentum, which takes advantage of the learning goals and inquiry-based guided learning sequences in a previously validated Quantum Interactive Learning Tutorial (QuILT). The in-class evaluation of the CQS using peer instruction is discussed by comparing upper-level undergraduate students' performance after engaging with the CQS with previous published data from the QuILT pertaining to these concepts.

POS1E26 (7:45 to 8:30 PM MONDAY) Effect of Guided Retrieval Practice and Feedback on Physics Problem-Solving

Poster – Presenting Author: Tianlong Zu, Jacksonville State University

Additional Author | Nobel Sanjay Rebello, Purdue University

Problem-solving and long-term retention of knowledge are important goals in physics learning. Retrieval practice, as a method shown to be effective promoting retention of studied material, is seldomly used in physics classroom. This work examines the effect of guided retrieval practice in terms of questions and feedback in terms of question answers or lecture video summary on college students' problem solving as well as one-week delayed retention performance. We found that students who practiced guided retrieval outperformed those practiced restudy regardless of the type of feedback. The effect is prominent when the problems used on the test are isomorphic to the guided questions during retrieval than when they are transfer questions. Students who just restudied the material also overpredicted their performance compared to the retrieval group. This difference in performance judgment disappeared after seeing the feedback. Overall, we found evidence supporting the effectiveness of retrieval practice in physics learning

POS1E27 (7:00 to 7:45 PM MONDAY) Negative Impacts of an Unwelcoming Physics Environment on Undergraduate Women

Poster – 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.

POS1E28 (7:45 to 8:30 PM MONDAY) Module Analysis of the Brief Electricity and Magnetism Assessment

Presenting Author: Christopher Wheatley, West Virginia University

Additional Author | James Wells, University of Connecticut

Additional Author | John Stewart, West Virginia University

The Brief Electricity and Magnetism Assessment (BEMA) is a multiple-choice instrument measuring a student's conceptual understanding of electricity and magnetism. This study applied modified module analysis—partial (MMA-P), a network analytic method that identifies groups of responses using partial correlations, correcting for overall instrument score, to post-test BEMA data from one institution over many years (N =12,214). In module analysis, groups of correlated responses are called "communities." As in previous applications of MMA-P to mechanics conceptual inventories, a number of communities related to physics concepts and some communities related to the structure of blocked items in the inventory were identified. This work supports previous results of an analysis of the Conceptual Survey of Electricity and Magnetism that suggest the existence of a rich collection of misconceptions and naïve conceptions about electricity and magnetism which are consistently applied by students after instruction in introductory physics.

POS1E29 (7:00 to 7:45 PM MONDAY) Exploring the Factors Affecting the Expert-like Scientific Attitudes

Poster – Presenting Author: Dona Hewagallage, West Virginia University

Additional Author | John C Stewart, West Virginia University

This study investigates the three facets of the Colorado Learning Attitudes about Science Survey (CLASS): personal application, personal effort, and problem-solving. The sample consists of students from a large eastern land-grant university enrolled in Physics 1 (calculus-based mechanics class). These students are primarily pursuing engineering degrees. Item Response Theory (IRT) estimates a latent variable capturing expert-like scientific attitudes. Correlations among the variables: the latent variable, the facets, FMCE pretest, and post-test scores, course grade, ACT/SAT scores, and general high school preparation school are calculated, and regression analysis is done to explore what factors explain the variance in each facet and the latent variable and to what degree.

POS1E30 (7:45 to 8:30 PM MONDAY) Scientific Argumentation in the Secondary Physics Classroom*

Poster – Presenting Author: Guofu Ma, Department of Teaching and Learning, the Ohio State University

Additional Author | Lin Ding, Department of Teaching and Learning, the Ohio State University

Additional Author | Zac Patterson, Department of Teaching and Learning, the Ohio State University

This study is aimed at exploring the ways high school students engage in scientific argumentation and the impact of argumentation on student learning. We observed a three-week unit on Newton's laws in an algebra-based mechanics course taught by an experienced physics teacher who is skilled in modeling instruction at a sub-

urban public high school in Ohio. Thirty students in the class worked in groups of 4 or 5 on modeling activities . We videotaped a student focus group, interviewed the teacher and individual students, and collected student artifacts, including workbooks and whiteboard pictures. These sources of data were analyzed iteratively to capture students' scientific argumentation instances. We claim that modeling instruction can inherently promote deep forms of inquiry, argumentative events, and by extension scientific argumentation skills.
*Our data show that the teacher faltered on making the argumentative practice explicit, as she did not consider the canonical science content as a suitable topic for argumentation in class. This suggests that a more content-specific framework is needed for instructors to better engage students in argumentation activities.

POS1E31 (7:00 to 7:45 PM MONDAY) Qualitative Social Network Analysis of Women and LGBT+ Professional Physicists

Poster – Presenting Author: Camila Amaral, University of Utah

Additional Author | Ramón Barthelemy, University of Utah

Additional Author | Madison Swirtz, University of Utah

Additional Author | Justin A Gutzwa, University of Utah

Additional Author | Evan LaForge, University of Arizona

Part of a successful career trajectory in physics is building and maintaining a professional network of peers, collaborators, and mentors that can support one's self in finding new opportunities and professional growth. This is known to be challenging for marginalized groups, such as women and lesbian, gay, bisexual, and transgender (LGBT) persons, and may be one of the reasons that these groups face challenges in physics. Therefore, there is a need to research on networks of women and LGBT physicists. In this qualitative Social Network Analysis (SNA) study, data is collected through in-depth semi-structured interviews by video conference with participants who are women and/or LGBT, hold a PhD in physics and work in the academic, private, or government sectors. Participants were asked to draw sociograms that provide visual information about personal and professional connections relevant to them. Preliminary findings will be presented.

POS1E32 (7:45 to 8:30 PM MONDAY) Investigating Students' Strengths and Difficulties in Quantum Computing

Poster – Presenting Author: Tunde Kushimo, Texas Tech University

Additional Author | Beth Thacker, Texas Tech University

The field of quantum computing is presently gaining tremendous attention from governments, researchers, engineers, academics and investors. There is an ongoing push for the development of quantum computers, advances in information technology, and the development of a quantum workforce. This needs to be accompanied by the development of quantum computing courses and curricula and the development and adoption of evidence-based materials and pedagogies to support the education of the next generation of quantum information scientists At Texas Tech University (TTU), we have introduced a course in Quantum Computing and have begun to research student understanding of topics in this field. Our goal is to develop evidence-based materials for the course. We did a series of interviews to identify students' strengths and difficulties in these topics. We report on the results of these interivews and our initial work on the development of supplementary materials for the course.

POS1E33 (7:00 to 7:45 PM MONDAY) White Male Physicists Sense-Making Around Equity in STEM

Poster – Presenting Author: Melissa Dancy, Western Michigan University

Additional Author | Apriel Hodari, Eureka Scientific

Additional Author | Charles Henderson, Western Michigan University

Additional Author | Nanah Apkarian, Arizona State University

Additional Author | Estrella Johnson, Virginia Tech University

While the majority of white men in physics value racial and gender equity, they frequently engage in patterns of thought, speech, and action that undermine these values. We use data from two studies to highlight some of these patterns. One study is based on a large survey of faculty (n=1023) and one based on intensive interviews of white male faculty and graduate students (n =27). Identifying and naming these patterns can help researchers, advocates and white men become aware of these patterns and work to address them. For example, they view inequity as happening outside their sphere of influence, minimize its impacts, and show little understanding of the experiences of those around them of different demographics.

POS1E34 (7:45 to 8:30 PM MONDAY) Development of a Likert-style Instrument to Assess LA's PCK-Q*

Poster – Presenting Author: Kyle Wipfli, Texas Tech University

As part of a project to develop a written instrument for assessing learning assistants' (LAs') pedagogical content knowledge (PCK) in the context of questioning (PCK-Q), we are experimenting with questions in a Likert-style format. Previously, we have developed and validated questions in free-response format. We are now using those questions as the basis for Likert-style questions. Likert-style questions are different because they require the LAs' to evaluate possible LA responses to students in classroom scenarios. They are also beneficial because scoring can be automated. The instrument will examine a LA's ability to identify appropriate responses that provide evidence of the application of PCK-Q in the classroom. We will discuss problem development, present sample problems, and future plans.
*Funded by NSF IUSE grant 1838339

POS1E35 (7:00 to 7:45 PM MONDAY) Assessing Thinking Skills in Free-response Exam Problems: Covid vs. Non-covid

Poster – Presenting Author: Jordan Johnson, Texas Tech University

Additional Author | Fatema Al-Salmani, Texas Tech University

Additional Author | Beth Thacker, Texas Tech University

We designed a rubric to assess free-response exam problems in order to compare thinking skills evidenced in exams in classes taught by different pedagogies. The rubric was designed based on Bloom's taxonomy (revised version) [1-3]. It was then used to code exam problems. We are now using this rubric to analyze the thinking skills of students taught online during covid vs. students taught in class after covid. We analyzed exams from different sections of the algebra-based physics course taught online during covid and in class after covid. We discuss the instrument, present results and future research plans.

POS1E36 (7:45 to 8:30 PM MONDAY) Exploring the Reliability of Natural Language Processing Models Across Populations

Poster – Presenting Author: Patrick Johns, Michigan State University - East Lansing, MI

Additional Author | Heather J Lewandowski, University of Colorado Boulder

Additional Author | Rachel Henderson, Michigan State University

Open-ended student responses to assessments probing their understanding often contain information about student reasoning that closed-ended responses fail to capture. The Physics Measurement Questionnaire (PM MONDAYQ) is an open-ended assessment tool designed to measure student understanding of measurement uncertainty. We collected student responses to the PM MONDAYQ from those enrolled in the two-semester Design, Analysis, Tools, and Apprenticeship Lab course at Michigan State University. The responses were hand-coded by researchers into one of three paradigms for student reasoning about measurement uncertainty: point-like, set-like, or undefined. Here, I will discuss how we used these data to train and test a multi-class logistic regression model. The accuracy and the highest weighted features (words) will be presented and then compared with an equivalent model developed using student data at the University of Colorado, Boulder. The comparison supports a conclusion that models trained on open-ended student responses to the PM MONDAYQ are robust under small population differences.

POS1E37 (7:00 to 7:45 PM MONDAY) Learning to Teach, Teaching to Learn: Peer Coaches and Metacognition

Poster – Presenting Author: Jonathan Kustina, University of New Hampshire

Additional Author | Amanda Gaudreault, University of New Hampshire

Additional Author | Kathleen Bowe, University of New Hampshire

Additional Author | Michael Briggs, University of New Hampshire

Additional Author | Dawn Meredith, University of New Hampshire

In efforts to improve college-level introductory STEM courses, many universities have turned to student partnership strategies to increase engagement and performance. At UNH, these "gateway" STEM courses employ either learning assistants or peer-led team learning leaders to bridge the gap between students and instructors. Our peer coaches come from many majors: physics, chemistry, mathematics, and biology. Our DBER group works with both instructors and peer coaches involved in introductory courses, with a focus on developing strong scientific, mathematical, and metacognitive practices. My work focuses on uncovering how peer coaches can serve not just as content coaches, but metacognitive coaches as well. We are investigating how peer coaches confer ideas and strategies about metacognition, reinforce students' use of them, and utilize them in their own learning processes. I will present initial data from peer coach reflection journals written for their introductory pedagogy course to better understand the role of metacognitive coach.

POS1E38 (7:45 to 8:30 PM MONDAY) Student Learning of Photoelectric Effect Using Simulations and Reflective Writing

Poster – Presenting Author: Tiffany Taylor

This action-research project is the culmination of a semester-long course called Modern Physics for Educators. In this study, I examined how active learning using PhET simulations and Pivot Interactives affect student learning of physics as well as their attitudes and beliefs about physics, and what impact,if any, reflective writing had on student learning outcomes. This poster aims to address the following research questions:

1) Does an active learning approach using simulations correlate with student learning of physics content?
2) How do students' incoming beliefs about physics impact their learning of physics?
3) How does reflective writing impact student learning outcomes and attitudes toward physics?

Session EA: Building a Quantum Information Science and Engineering Curriculum for a Diverse Community of Learners I

Location: CC: Grand Gallery A **Sponsor:** AAPT
Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** Todd Zimmerman

EA01 (8:00 to 8:30 AM TUESDAY) Progress Report on K-12 Quantum Education

Invited – Presenting Author: Emily Edwards, University of Illinois Urbana Champaign

In the Fall of 2020, the National Q-12 Education Partnership was launched and numerous programs for quantum workforce development came online. In the long-term, emergingprograms have the potential to help young learners develop an appreciation for quantum information science and engineering (QISE), and even inspire students to pursue a career in this critical area. In addition, introducing QISE concepts early may help students develop intuition around this topic, and prepare them for future QIS coursework. Extending QISE learning opportunities to younger age groups is also critical towards the development of a more inclusive, diverse quantum workforce and engaged public. I will give an update on the developing quantum education ecosystem for K-12 learners, educators, and stakeholders. I will also report on the outcomes of an informal quantum education program called QuanTime, which launched for World Quantum Day 2022.

EA02 (8:30 to 9:00 AM TUESDAY) TBD

Invited – Presenting Author: Leron Gil

Session EB: Diversifying Through Connections at TYCs I

Location: CC: Grand Gallery B **Sponsor:** Committee on Diversity in Physics
Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** Kris Lui

EB01 (8:00 to 8:30 AM TUESDAY) Diversity in Physics in TYCs: People, Places, and Pedagogy

Invited – Presenting Author: Susan White, AIP Statistical Research Center

Using data from the American Institute of Physics' Statistical Research Center 2011-12 Survey of Physics in Two-Year Colleges, we will look back at various facets of diversity in physics in two-year colleges including students and faculty members (people), academic units (places), and variety in course offerings (pedagogy). Using more recent data from the National Science Foundation (NSF) and the US Department of Education's Integrated Postsecondary Education System (IPEDS), we will examine trends in two-year college student diversity since 2012. In addition, using data from College Board, we will explore the impact of the pandemic on enrollments and retention for students at two- and four-year colleges.

EB02 (8:30 to 9:00 AM TUESDAY) TYC Interests and Needs, and DEI Materials

Invited – Presenting Author: Glenda Denicolo, Suffolk County Community College

In this presentation we will share the preliminary information collected from an interests-and-needs survey of TYC physics faculty. We will also report and share ideas about DEI initiatives at some TYCs, and discuss the need for more physics-centered DEI resources.

Session EC: High Altitude Ballooning I

Location: CC: Grand Gallery C **Sponsor:** Committee on Educational Technologies
Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** Erick Agrimson

EC01 (8:00 to 8:30 AM TUESDAY) Nationwide Eclipse Ballooning Project: Approaches for Guiding Student Learning

Invited – Presenting Author: Angela Des Jardins, Montana State University

The focus of the NEBP is to broaden participation of STEM learners by immersing teams from a wide range of higher education institutions in an innovative NASA-mission-like adventure in data acquisition and analysis through scientific ballooning during the 10/14/2023 annular and 4/8/2024 total solar eclipses. NEBP will engage 85 teams in equitable, inclusive learning on two primary tracks: 1) atmospheric science and 2) engineering. Engaging 85 teams spread across the country will be a challenge. The teams will be from a variety of college types, the students will have different background knowledge levels, and the available mentoring will vary. To meet these challenges, the teams will be divided into ten geographic pods, five for each track. Each pod has a Pod Lead who will create a cohesive community with their 8-10 teams. This talk will describe how NEBP will engage the student participants, both at the pod level and nationally.

EC02 (8:30 to 9:00 AM TUESDAY) Overview of Educational Applications of Lighter-Than-Air Ballooning

Invited – Presenting Author: James Flaten, U of MN - Twin Cities & NASA's MN Space Grant Consortium

Lighter-than-air ballooning ranges from flame-carrying "sky lanterns" (not a recommended activity) that have been flown for centuries, to the earliest balloon flights carrying people in 1783, to the largest flying vehicles – the amazing airships from the decades before WWII, to rubber and mylar "party" balloons, to tourist-carrying hot-air balloons, to home-built solar balloons, to pico-balloons capable of circumnavigating the earth (multiple times!), to latex-rubber weather balloons, zero-pressure balloons, and super-pressure balloons capable of carrying curricular and research payloads into the stratosphere. Lighter-than-air ballooning provides a context

for students of all ages to study aviation history and to do many engaging STEM lessons ranging from studying buoyancy and the properties of lifting gases, to measuring the extreme conditions of the atmosphere and studying weather/climate, to predicting balloon trajectories and tracking flights, to building and operating "near-space" vehicles, to doing photography and remote sensing, to programming microcontrollers and analyzing sensor data.

Session ED: General Topic Papers

Location: CC: Grand Gallery F **Sponsor:** AAPT

Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

ED01 (8:00 to 8:10 AM TUESDAY) In-medium Decay Constant of Y(4008) and ψ(4040) State

Contributed – Presenting Author: Dr Rahul Chhabra, Sanjay Ghodawat International School, Kolhapur

I investigate the partial decay constant of Y(4008) and \psi(4040) states decaying to open charm and anti-charm pairs in symmetric nuclear medium at finite temperature. 3P0 model is used to observe the partial decay widths and the impact of finite nuclear medium and finite temperature is observed through the medium modification of open charm mesons using chiral SU(3) + QCD sum rule approach calculated in my previous work. In the present work \psi(4040) and Y(4008) states are supposed to be 3S1 states. The results of the present work may help in future to assign the exact spectroscopic notation to Y(4008) state.

ED02 (8:10 to 8:20 AM TUESDAY) Trends in Physics Higher Education

Contributed – Presenting Author: Brad Conrad, Society of Physics Students @ AIP

Additional Author | Rachel Ivie, American Institute of Physics

As departments aim to build thriving programs, being aware of the changing landscape of higher education and current trends within recruitment and retention for undergraduate and graduate programs is vital to best serve students while preparing them for a broad array of career outcomes. This talk will briefly outline recent trends in higher education, department climate data, and will aim to connect a program's educational outcomes to pragmatic resources for student leaders and faculty alike.

ED03 (8:20 to 8:30 AM TUESDAY) Modification of Newton's Second Law of Motion

Contributed – Presenting Author: Amritpal Nafria

In this paper, calculation of force applied by a body onto another body under the effect of various resistances has been studied practically. It has been observed that in every action some part of the applied force is required to overcome the effect of resistances (friction, air resistances, etc.) that ceases body's motion. Therefore, a mathematical expression of applied force 'F=ma+r' has been provided by including a factor describing effect of resistances. To calculate the effect of resistances, weighing scale has been proposed. This paper concludes that when equal force is applied to same mass for multiple times, the acceleration varies when the effect of resistances varies. Moreover, using this concept, some cases are explained such as; the nature of the acceleration when increase applied force on a body moving at the speed of light; nature of applied force when mass of body changes during acceleration.

ED04 (8:30 to 8:40 AM TUESDAY) Inspiring the Next Generation of Students in Physics and Astronomy

Contributed – Presenting Author: Kayla Stephens, Society of Physics Students, AIP

How physics and astronomy is presented to K-12 students can help determine how they declare their academic major in college. Students tend to declare their major based on personal, interpersonal, or practical reasons. This talk will focus on how students can see themselves at your institution, how undergraduate clubs can retain them once they are there, and the tools that the Society of Physics Students can offer to help inspire and reinforce K-12 students' interest in physics and astronomy. This pragmatic talk will outline steps you can take to connect them to physics and astronomy and be their academic choice in college.

ED05 (8:40 to 8:50 AM TUESDAY) Using Natural Language Processing in Clustering Student Behaviors

Contributed – Presenting Author: Tom Zhang, University of Central Florida

Additional Author | Zhongzhou Chen, University of Central Florida

Analyzing student's Self-Regulated Learning (SRL) behaviors has become increasingly important with the rise in prevalence of online learning during the pandemic; distinguishing between adaptive and maladaptive learning behaviors can help improve quality of instruction and provide instructors with information as to what course content is effective or requires changes. Recent studies have handled this categorization through labeling micro-interactions with online learning environments under the framework of SRL and clustering behaviors from patterns of these interactions. A key assumption of these studies involves expert input in mapping log events onto SRL actions, which can be a labor and time intensive process. In exploring whether or not meaningful clustering can be achieved without requiring expert input, we applied the word2vec algorithm to traces (or sequences) of student interaction with learning materials and coupled with DBSCAN to identify event sequence strategy clusters based on semantic similarity.

Session EF: PER: Diverse Investigations I

Location: CC: Grand Gallery E- **Sponsor:** Committee on Research in Physics Education
Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

EF05 (8:00 to 8:10 AM TUESDAY) Development of Self-Efficacy in an Advanced Physics Lab

Contributed – Presenting Author: Catherine Herne, SUNY New Paltz

In this study we examine the impacts of elements of an advanced physics lab on 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 introductory physics courses and introductory physics labs, examining changes in a student's self-efficacy based on aspects of course design and student interactions. The advanced physics lab offers a new arena in which to investigate these changes. While students are all majoring in physics, there is significant variation between students in their confidence in their abilities. In addition, their experimental design and execution skills are typically not developed at the start of the course. We will discuss how the use of particular course elements change a student's self-efficacy and make recommendations based on our results.

EF02 (8:10 to 8:20 AM TUESDAY) A Mixed Methods Approach Towards Defining Students' Ranges of Self-Efficacy

Contributed – Presenting Author: Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Research on self-efficacy - or the confidence in one's capability to execute a task - has been shown to predict science achievement and persistence. As students navigate curricular and/or co-curricular activities, they may experience threats to their self-efficacy. To investigate these threats and supports, we conducted a study using a novel mixed methods design. Quantitatively, we employed the Experience Sampling Method (ESM) using surveys of domain-specific self-efficacy. Qualitatively, we used daily reflections to investigate threats and supports toward students' self-efficacy. Through the lens of one student, we will present our analysis which leverages an individual's interquartile range to identify moments that are indicative of low, normal, and high task-specific self-efficacy for a student.

EF03 (8:20 to 8:30 AM TUESDAY) Using Machine Learning to Predict Student Performance in Introductory Mechanics

Contributed – Presenting Author: John Pace, West Virginia University - Morgantown, WV

Additional Author | John Stewart, West Virginia University - Morgantown, WV

Additional Author | John Hansen, West Virginia University - Morgantown, WV

Logistic regression and random forest classification models were used to predict students at risk of receiving a failing grade (D or F) in an introductory mechanics class (N = 2061 students). The dataset consisted of both institutional and in-class variables gathered from the first two weeks of instruction, with the in-class variables (homework and clicker scores) found to be particularly important for the model's classification accuracy. Additional methods such as model regularization and upsampling of the failing class through the synthetic minority oversampling technique (SMOTE) were found to slightly improve model performance. The best performing models achieved a balanced accuracy of around 80%. An apparent performance ceiling of around 87% was found by providing the model with the course test average, indicating that substantially increasing performance above 80% is unlikely with data available early in the semester.

EF04 (8:30 to 8:40 AM TUESDAY) How Social Psychological Variables Affect Students' Performance in Introductory Physics

Contributed – Presenting Author: Qing Ryan, Cal Poly Pomona

Additional Author | Viviane Seyranian, Cal Poly Pomona

Additional Author | Nina Abramzon, Cal Poly Pomona

Additional Author | Ian Thacker, The University of Texas at San Antonio

Additional Author | Nicole Duong, Cal Poly Pomona

Additional Author |Alex Madva, Cal Poly Pomona

Social psychological measures such as students' interest, motivation, utility value towards physics could affect students' learning outcomes. In this study, we collected pre and post survey data of psychological measures such as Interest, Utility value, Math anxiety from the first semester of calculus-based introductory physics courses at Cal Poly Pomona (both a Primarily undergraduate institution and a Hispanic serving institution). In this talk, we discuss whether the relationship between membership in an under-represented demographic group and course grades are mediated by psychological measures such as Interest, Utility value and Math anxiety.

EF05 (8:40 to 8:50 AM TUESDAY) Becoming an Informal Physics Program Leader: Experiences and Choices

Contributed – Presenting Author: Bryan Stanley, Michigan State University

Additional Author | Kathleen Hinko, Michigan State University

Some university physics students volunteer in informal physics programs like youth camps, demo shows, and public lectures. These experiences help physics student volunteers to build connections with faculty and their peers, connect their formal learning to the real world, and support their physics identity. These experiences can also influence the career pathways of their participants. Here, we examine the career experiences of alumni who had volunteered in informal physics as students and have since gone on to become informal physics program leaders. By looking at this subgroup, we hypothesize that program leaders had some impactful informal physics experiences that led them to careers in informal education. We can use this as an initial step to understanding the commonalities in experiences for volunteers more broadly. The resulting themes could be of use to practitioners in better understanding and improving their own programs.

EF06 (8:50 to 9:00 AM TUESDAY) Network Analysis of the BEMA with Modified Module Analysis-Partial

Contributed – Presenting Author: Christopher Wheatley, West Virginia University

Additional Author | James Wells, University of Connecticut

Additional Author | John Stewart, West Virginia University

The Brief Electricity and Magnetism Assessment (BEMA) is a multiple-choice instrument measuring a student's conceptual understand-

ing of electricity and magnetism. This study applied modified module analysis—partial (MMA-P), a network analytic method that identifies groups of responses using partial correlations, correcting for overall instrument score, to post-test BEMA data from one institution over many years (N =12,214). In module analysis, groups of correlated responses are called "communities." As in previous applications of MMA-P to mechanics conceptual inventories, a number of communities related to physics concepts and some communities related to the structure of blocked items in the inventory were identified. This work supports previous results of an analysis of the Conceptual Survey of Electricity and Magnetism that suggest the existence of a rich collection of misconceptions and naive conceptions about electricity and magnetism which are consistently applied by students after instruction in introductory physics.

Session EG: PER: Student and Instructor Support & Professional Development, Program and Institutional Change II

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Research in Physics Education
Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

EG01 (8:00 to 8:10 AM TUESDAY) Predictors of Faculty Sentiment on Their Transition to Online Teaching

Contributed – Presenting Author: Jillian Mellen, Drexel University

Additional Author | Eric Brewe, Drexel University

Additional Author | Adrienne L. Traxler, Wright State University

Additional Author | Sarah Scanlin, Drexel University

Additional Author | Colin Green, Drexel University

In the spring and summer of 2020, we collected data on faculty experiences during their transition to online teaching as a result of the COVID-19 pandemic. Data on the participants' institutions, job security and position, resources used, changes in course grading, and preparation time were collected, as well as a free text response to add anything the participants felt was relevant. In total, 364 text responses were collected. Using natural language processing tools, we calculated sentiment scores for each response. The sentiment was found to be overall positive. In order to identify predictors of sentiment, we used LASSO regression. LASSO regression allowed us to first eliminate predictor variables and then identify meaningful predictors. Results indicate that being from a Minority-Serving Institution, preparation time, using their university's Department of Education as a resource, and allowing students to resubmit work all predicted sentiment.

EG02 (8:10 to 8:20 AM TUESDAY) A Leadership Institute's Role in Supporting Team-based Departmental Change

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

Additional Author | Joel Corbo, University of Colorado Boulder

Additional Author | David A Craig, Oregon State University

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

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

Challenges and opportunities emerge in the volatile landscape of higher education. These challenges and opportunities motivate physics departments to pursue change efforts in their undergraduate programs. APS initiated the Effective Practices for Physics Programs (EP3) project to help physics departments learn and engage in effective change. Part of this EP3 project is the Departmental Action Leadership Institute (DALI) which is a year-long institute for physics faculty pursuing departmental change. Through their participation in the DALI, physics faculty learn about change practices and are offered ongoing guidance on how to create, lead, and sustain local Departmental Action Teams (DATs) around change efforts. In this talk, I will introduce the goals and structure of the DALI. I will also describe the EP3 research goals that aim to document the role of the DALI in supporting broad stakeholder engagement, problem-scoping, and effective use of data within local departmental change efforts.

EG03 (8:20 to 8:30 AM TUESDAY) Team-based Approaches to Programmatic Resources: Who the Guide Really Guides

Contributed – Presenting Author: Robert Dalka, University of Maryland, College Park

Additional Author | Diana Sachmpazidi, University of Maryland, College Park

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

The Effective Programs for Physics Programs (EP3) Guide is an online, living document, that serves as a resource for departments seeking to improve or make changes to their undergraduate physics programs. The guide is based on past successful practices, identified by practitioners and researchers in physics education. Understanding how departments interact with the guide is of major interest, both to the EP3 project and other initiatives that aim to create resources for physics programs. In this presentation, we describe and compare how two different physics programs structure team-based approaches to using the EP3 Guide. Through data gathered during team meeting observations and individual team member interviews, we showcase how different stakeholders, within each respective team, develop understandings of the guide and connect it to their local contexts. Our findings shed light on how these resources become embedded (or not) in departmental joint work and become meaningful to specific departmental actors.

EG04 (8:30 to 8:40 AM TUESDAY) Supporting Physics Instructors to Facilitate Effective and Inclusive Group Work

Contributed – Presenting Author: Xian Wu, University of Connecticut, Storrs

Additional Author | Mona Peyravi, University of Connecticut, Avery Point

Additional Author | Matthew Guthrie, University of Connecticut, Storrs

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

The impact of active learning courses on students greatly depends on how students work in groups. It takes more than placing students in groups for group work to be effective and inclusive. Instructors' knowledge, attitudes, and beliefs about group work has been shown to have a tremendous impact on students' experiences and their performance. As part of a larger project aimed at supporting faculty to foster effective and inclusive group work, we interviewed studio physics instructors about how they use group work in their courses. We also surveyed students in these instructors' courses about their attitudes and beliefs about group work. We analyzed the relationship between the instructional practices used by instructors and the impact of these practices on students' learning and attitudes about the course. In this presentation, we will report preliminary findings comparing the interview and survey data with implications for instructors and researchers.

EG05 (8:40 to 8:50 AM TUESDAY) Challenges and Benefits of Remote Undergraduate Research: A Longitudinal Study

Contributed – Presenting Author: Dina Zohrabi Alaee, Rochester Institute of Technology

Presenting Author | Dina Zohrabi Alaee, Rochester Institute of Technology

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

In the summer of 2020, COVID-19 limited in-person undergraduate research programs and created additional barriers for many students by working from home. We present a longitudinal qualitative analysis of students' experiences in remote Research Experience for Undergraduate (REU) programs. By drawing on Cultural-Historical Activity Theory as a social cognitive framework for learning, we looked at REU programs as goal-directed activity systems. Within the activity system, we identified the challenges and benefits of this new remote format. Overall, 70 interviews were conducted with 10 mentees at seven points in time. Our findings revealed many similar benefits to in-person undergraduate research. However, we also found challenges in the remote format, such as technical difficulties at home, a lack of community, and low motivation. Remote research programs could be used to expand access to research opportunities for some students, but programs should pay attention to factors that may lead to negative experiences.

EG07 (8:50 to 9:00 AM TUESDAY) Investigating the Effect of Discipline in Mixed-reality STEM GTA Training

Contributed – Presenting Author: Daniel Sharkey, University of Central Florida

Additional Author | Constance M. Doty, University of Central Florida

Additional Author | Jacquelyn J. Chini, University of Central Florida

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

Student-centered introductory laboratory and recitation sessions are frequently led by graduate teaching assistants (GTAs) who have varied teaching experiences. GTAs from chemistry and physics participated in a professional development intervention designed to prepare graduate students for active learning. The project included GTAs rehearsing pedagogical skills during four training sessions in a mixed-reality teaching simulator. In each session, groups of two or three GTAs taught a lesson to five avatar-students, observed the other GTAs in their session rehearse, and participated in group feedback discussions. We compare GTAs' use of "Stretch-It", a questioning technique, in disciplinarily-homogenous (Chemistry or Physics GTAs only) groups to disciplinarily-mixed (Chemistry and Physics GTAs) groups by comparing how GTAs used questioning within and across the simulator sessions. Then, we analyze the feedback discussions for two groups, one physics-only group and one disciplinarily-mixed group. Finally, we discuss benefits and drawbacks of this type of interdisciplinary collaboration.

Session EH: PER: Professional Skills for Students

Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Research in Physics Education/ Committee on Graduate Education in Physics
Time: 8–9 a.m. **Date:** Tuesday, July 12 **Presider:** Phoebe Sharp

This interactive panel focuses on developing professional skills for graduate students and other early-stage researchers. This session will address professional concerns brought up by graduate students during the past Graduate Student Topical Discussions. Topics covered may include preparing for careers after graduate school, becoming integrated with the community, developing research skills, and disseminating your work. While this session is aimed toward graduate students, we welcome undergraduates who are interested in this professional development opportunity or curious about life as a graduate student!

Session FA: Best Practices in Educational Technology II

Location: CC: Grand Gallery A **Sponsor:** Committee on Educational Technologies
Time: 9:10–10:10 a.m. **Date:** Tuesday, July 12 **Presider:** Duncan Carlsmith

FA01 (9:10 to 9:20 AM TUESDAY) Improving Assignments using the Nbgrader Extension for Jupyter

Contributed – Presenting Author: Calvin Berggren, Texas Lutheran University

Jupyter has become a widely used tool in recent years especially for computational physics. Nbgrader is an extension for Jupyter that assists in building, managing, and grading assignments using Jupyter. This talk will discuss specific ways I use nbgrader to improve assignments in computational and theoretical physics.

FA02 (9:20 to 9:30 AM TUESDAY) Simulating Scientific Collaboration and Model Refinement With Virtual Reality

Contributed – Presenting Author: Jared Canright, University of Washington Department of Physics

Additional Author | Suzanne White Brahmia, University of Washington Department of Physics

The Novel Observations in Mixed Reality (NOMR) project at the University of Washington uses virtual reality (VR) technology to create a space where students experience and investigate fictitious physical phenomena to develop their scientific modeling skills. NOMR has been developed into the Manifold Lab, a four-week lab emulating the experience of working within a scientific collaboration to iteratively create, test, and refine mathematical models for novel phenomena. In this talk we present the Manifold Lab in detail. We discuss how it creates a microcosm of the authentic practice of science in a collaborative setting. Findings from research into its impacts on students' epistemology about experimental physics are presented. Finally, we explore other ways VR can be used to put students in the shoes of practicing scientists.

FA03 (9:30 to 9:40 AM TUESDAY) Live Script Tutorials in Computational Magnetism

Contributed – Presenting Author: Duncan Carlsmith, University of Wisconsin - Madison

Three interactive MATLAB Live Script tutorials in computational magnetism for first year university students are described. These tutorials explore magnetic fields of finite solenoidal and toroidal current-carrying helical coils, permanent magnets, and a complex analytic expression for the field of a cylindrical current sheet. The tutorials supplement laboratory experiences in electromagnet and permanent magnet field mapping and in eddy currents and induction.

FA04 (9:40 to 9:50 AM TUESDAY) Gamifying Simulation to Improve Understanding and Attitudes Towards Electric Fields

Contributed – Presenting Author: Colleen Countryman, Ithaca College

Presenting Author | Ted K Mburu, Ithaca College

Because electric fields cannot be touched or seen, simulations are often utilized to enhance students' understanding of them by providing them with a visual representation of electric fields and the motion of test charges within them. We built and tested an electric field "sandbox" simulation that dynamically represents the electric field lines, field vectors, equipotential lines, and the voltage of the charges that the user places anywhere on the screen. We then gamified the simulation with the intent of further improving motivation and engagement in the material. Everything we created was built in JavaScript, so they will run on most browsers on a computer or mobile device. Results and student feedback from a subsequent controlled study of the efficacy of these instructional tools will be discussed. The results indicated that no individual tool was significantly more effective than the others, but pre- to post-diagnostics were significant across all three groups.

FA05 (9:50 to 10:00 AM TUESDAY) Using the TopHat Platform to Minimize Costs for Students

Contributed – Presenting Author: Andrew Duffy, Boston University, Physics Department

TopHat is a platform known for in-class quizzing, with students using their phones to respond to questions. However, in our two-semester introductory algebra-based physics sequence, we are leveraging the TopHat platform to do significantly more than that. In addition to the in-class clicker feature, we are using TopHat for (1) optional pre-class preparation, with quizzes that include videos, content, and feedback from the students to the instructor; (2) online homework; (3) an interactive e-book, with a significant number of embedded simulations; and (4) collecting and grading lab reports. The vast majority of the materials were created by us, with a goal of making high-quality content available to the students for a reasonable cost. The interactive e-book is available for adoption by others for $20/student/semester. For our students this puts the total cost of the course materials at $46/student/semester (e-book + TopHat fee).

FA06 (10:00 to 10:10 AM TUESDAY) Incorporating Affect in the Design of Interactive Web-based Problem-solving Tutorials*

Contributed – Presenting Author: Kathleen Koenig, University of Cincinnati

Additional Author | Alexandru Maries, University of Cincinnati

Additional Author | Robert Teese, Rochester Institute of Technology

Research on advanced learning technologies indicate that various emotional experiences or affect (e.g., engagement, boredom, frustration, confusion, worry) are triggered in specific situations. These emotions can facilitate or inhibit student learning, suggesting that emotional experiences should not be overlooked in the design of online learning environments. This presentation will showcase our web-based interactive video-enhanced tutorials (IVETs), which guide students through an expert-like problem-solving approach for a challenging problem involving a given topic, such as conservation of energy. IVETs include video narration by a live person interspersed with branching multiple choice questions that include feedback, allowing students who require less guidance to navigate the tutorials quickly, while students who struggle receive more support according to their needs. This presentation will highlight the design principles that guided the development of each IVET, with a particular focus on students' emotional experience. Data collected from log files, surveys, and student interviews will be shared.
*Supported in part by NSF DUE-1821391 and DUE-1821396.

Session FB: Building a Quantum Information Science and Engineering Curriculum for a Diverse Community of Learners II

Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Educational Technologies
Time: 9:10–9:50 a.m. **Date:** Tuesday, July 12 **Presider:** Todd Zimmerman

FB01 (9:10 to 9:20 AM TUESDAY) Diverse Pathways to the Quantum Industry at Q-SEnSE

Contributed – Presenting Author: Michael Bennett, Q-SEnSE NSF QLCI, University of Colorado Boulder

In addition to its rigorous basic-research QISE agenda, the Q-SEnSE NSF Quantum Leap Challenge Institute oversees a number of educational and workforce development initiatives based in quantum education research and designed to help facilitate a diverse and prepared quantum workforce. In this talk we will present two of these initiatives, highlighting in particular the institutional partnerships that form the foundation for their fruitful implementation. We will also discuss current efforts to connect education stakeholders in QISE and open a conversation on ways to move the field forward in the best interests of students as well as members of the quantum industry.

FB02 (9:20 to 9:30 AM TUESDAY) What Does it Mean to See Quantum Mechanics?

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

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

The second quantum revolution has prompted not only research in quantum science, but also research on how best to teach students who may enter this burgeoning field. Much of this conversation has focused around students' conceptual learning or skills desired by potential employers, while research on how lab experiments can contribute to undergraduate quantum education has been largely absent. In a recent survey of instructors using lab experiments with single and entangled photons, one of the most important learning goals was to "'see' quantum mechanics in real life." To better understand this goal, we investigate what seeing quantum mechanics means to instructors and why they believe it is an important part of students' education. We present emergent themes coming from a qualitative coding analysis of 15 instructor interviews, which begin to elucidate the role quantum lab experiments may play in undergraduate education.

FB03 (9:30 to 9:40 AM TUESDAY) QuSTEAM: Developing a Modular Curriculum for a Diverse QIS Community

Contributed – Presenting Author: Christopher Porter, The Ohio State University Department of Physics

Additional Author | Monica E Allen, North Carolina Agricultural and Technical University

Additional Author | Russell Ceballos, University of Chicago

Additional Author | Andrew Heckler, The Ohio State University

QuSTEAM (Quantum Information Science, Technology, Engineering, Arts and Mathematics) is a collaboration between several institutions (R-1s, HBCUs, and community colleges) working to build a national educational model for the emerging field of quantum information sciences (QIS). The development relies on research-based practices to provide a convergent and inclusive curriculum to a diverse community of future scientists and engineers, a curriculum that is modular and conducive to in-person, online, and hybrid delivery modalities. In this talk, we will present an outline of the work, which is still in early stages. We will describe emerging themes in training needs from the industry, as well as faculty and student priorities. Some overview of early modules will also be presented, as well as the processes used to develop these modules. Early data will be presented from a beta version of the first QuSTEAM course, using the context of a Stern Gerlach module.

FB04 (9:40 to 9:50 AM TUESDAY) Creating a Quantum Information Science and Technology Minor at RIT

Contributed – Presenting Author: Benjamin Zwickl, Rochester Institute of Technology

As quantum technologies become more widespread, there is an increased need for engineers, scientists, and software developers who are "quantum aware". Rochester Institute of Technology has developed a new multidisciplinary minor in Quantum Information Science and Technology that is designed to serve students from over a dozen STEM majors. The minor involved the creation of two courses, one in physics and one in computer engineering. The physics course focuses on foundational concepts of quantum mechanics, quantum computer hardware implementation, and non-computing applications of quantum technology, such as quantum sensing. The computer engineering course uses qubits and quantum gates as a starting point and focuses on algorithms, cryptographic applications, and the software stack linking the application to the underlying hardware. In this talk I will describe the factors that influenced our program design and our efforts to make the minor accessible to a broad range of majors.

Session FC: Diversifying Through Connections at TYCs II

Location: CC: Grand Gallery B **Sponsor:** Committee on Diversity in Physics
Time: 9:10–9:50 a.m. **Date:** Tuesday, July 12 **Presider:** Kris Lui

FCA01 (9:10 to 9:20 AM TUESDAY) Using Intrusive Advising to Improve Student Success

Contributed – Presenting Author: Tom Carter, College of DuPage

I will provide quantitative data on the improvement in student success rates caused by the use of a Student Success Coach at a large two-year college. The College of DuPage (COD) received a five-year grant from the National Science Foundation's Scholarships in Science, Technology, Engineering and Mathematics (S-STEM) program to provide support to approximately twenty STEM students per year. Selected students received full tuition scholarships, access to summer internships, guided study groups and STEM activities on campus. In addition, a key element of the support is the assignment of a Student Success Coach who provided close, personal attention to these particular students. In what is sometimes referred to as "intrusive advising", the Success Coach worked to intervene early before small issues become larger ones. COD has completed this first grant and is applying for a second grant to expand the program to part-time students. (NSF DUE Award #1564720)

FCA02 (9:20 to 9:30 AM TUESDAY) Embedded Academic Coaching at Montgomery College: Achieving the Promise Academy

Contributed – Presenting Author: Raymond Fermo, Montgomery College - Rockville, MD

Additional Author | Nik Sushka, Montgomery College - Rockville, MD

At Montgomery College, academic coaches embedded into core physics and engineering courses support student success through the Achieving the Promise Academy (ATPA). Beginning in 2016, the ATPA was established with the goal of closing the "achievement gap" by increasing the retention, persistence, graduation, and completion rates of underrepresented minorities. Through the program, personal

academic coaches serve more than 450 students annually, and embedded coaches support over 12,000 students across 700+ sections of courses. Academic coaches embedded into Physics I, Physics II, and Statics work closely with host faculty to support physics and engineering students in the foundational courses for their chosen major. Coaches have advanced degrees in their field and college-level teaching experience. In addition to tutoring, coaches support students holistically with academic habits, study skills, connections to campus resources, and promoting career development. Students in these courses have measurably higher course pass rates.

FCA03 (9:30 to 9:40 AM TUESDAY) Understanding Hispanic Physics Majors' Expectations of Relationship-Building at Community College

Contributed – Presenting Author: Anne Leak, High Point University

Additional Author | Peter Chung, University of Southern California

Additional Author | Chris Vaca, Rio Hondo College

A diverse physics workforce benefits society and the economy; yet, physics graduates do not reflect an inclusive community. Over 18% of the American population identifies as non-white Hispanic, though American Institute of Physics data show that only 9% of physics bachelor degrees were awarded to Hispanic students as of 2018. Community colleges are more representative of community demographics with 27% of students identifying as Hispanic and over 200 colleges federally recognized as Hispanic-Serving Institutions (HSIs), but community colleges do not serve as many physics majors compared to baccalaureate-granting institutions. 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 focuses specifically on Hispanic community college students' early expectations for building relationships with mentors and peers. Understanding these expectations will help faculty support URM students through their undergraduate research experiences and transitions to baccalaureate-granting physics programs.

FCA04 (9:40 to 9:50 AM TUESDAY) Community Building in Physics Classroom: A Pandemic Update

Contributed – Presenting Author: Jennifer Snyder, San Diego Mesa College

At the 2020 AAPT Winter Meeting, research on the effect of Community Building on underrepresented groups in an Introductory Physics course at San Diego Mesa College was presented. Data was presented showing an increase in success as these techniques were implemented. Then the pandemic hit. This presentation shows how these techniques were implemented in a remote setting and the effect on student success. It also reports on student success in different demographics in the aftermath of the pandemic and asks the question "How are our students doing?"

Session FD: Gender

Location: CC: Grand Gallery F **Sponsor:** AAPT

Time: 9:10–9:40 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

FD01 (9:10 to 9:20 AM TUESDAY) An Update on Women's Leadership in Physics Education

Contributed – Presenting Author: Laura McCullough, University of Wisconsin-Stout

In 2018, I presented a poster on the number of women in leadership roles in physics education. In this poster I will update the data and include some new data. From 2018: I will share data about the numbers of women in various leadership positions in physics education: editors, research group directors, professional organization roles. This data is more difficult to gather because of the short-term nature of people's time in these roles. But a snapshot in time of this data provides important information for the discussion of under-representation in physics.

FD02 (9:20 to 9:30 AM TUESDAY) Diversity of Performance and Choice of Physics by Female Students

Contributed – Presenting Author: Saeed Moshfeghyeganeh, University of New England

Additional Author | Zahra Hazari, Florida International University

Additional Author | Gerhard Sonnert, Harvard University

Additional Author | Philip M Sadler, Harvard University

The underrepresentation of women in physics is a well known phenomena in the US. However, literature suggests that women were are more likely than men to have both high math and verbal performance (Wang et al, 2013). Using nationally representative "FROST" data, we investigate how the diversity of performance affect female students' interest in physics compared to the male.

FD03 (9:30 to 9:40 PM TUESDAY) Impact of a Physics Camp on Girls' Critical Physics Identities

Contributed – Presenting Author: Madison Smith, Texas A&M University - Commerce

Additional Author | Robynne Lock, Texas A&M University - Commerce

Only about 20% of individuals earning bachelor's degrees in physics are women, and roughly 13% are underrepresented racial minorities (URMs). These numbers have remained relatively steady for more than a decade, thus there is a need to investigate ways to improve their representation in physics. Out-of-class science and engineering activities have been shown to influence students' career interests in physics. This study evaluates how a physics summer camp for high school girls influences the critical physics identities and career interests of the camp participants. We use a mixed-methods approach that includes conducting surveys and interviews. The survey results show overall positive shifts in critical physics identity. The interviews provide insight into which aspects of the physics camp contribute to these shifts as well as how the camp influences URMs.

FD04 (9:40 to 9:50 PM TUESDAY) Deserving of Nobel? The Harvard Computers and other Neglected Pioneers

Contributed – Presenting Author: Richard Gelderman, Western Kentucky University

"Should a Nobel prize have been awarded to Annie Jump Cannon, Cecilia Payne Gaposchkin, Henrietta Leavitt, Vera Rubin, Margaret Geller, or Jocelyn Bell Burnell? Locate, read, and cite at least three separate sources to justify your response." This assignment can be used at the beginning of a term to spark interest before students get deadened by their academic load, or can come at the end of the term as a capstone project. Providing a list makes the assignment appear more straightforward. However, since the top hits on the Internet pull up mostly female astronomers, to ask students to argue on behalf of any astronomer overlooked by the Nobel committee produces similar results while preventing any complaints that a social agenda is being pushed.

Session FE: High Altitude Ballooning II

Location: CC: Grand Gallery C **Sponsor:** AAPT **Time:** 9:10–9:50 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

FE01 (9:10 to 9:40 AM TUESDAY) Nationwide Eclipse Ballooning Project Engineering Systems Overview

Invited – Presenting Author: Randal Larimer, Montana Space Grant Consortium

This presentation highlights the technical engineering systems used to safely and successfully capture real-time video and data from a high-altitude weather balloon during the October 14, 2023 annular eclipse and the April 8, 2024 total solar eclipse. The engineering POD leads and their students have been carefully designing, documenting and testing the systems that will be distributed to the participating forty engineering teams. System components include an Iridium tracking system, a cutdown system, a tracking ground station, a streaming video system, a dual camera system providing 360 degree views, a helium vent valve system for latex balloons, zero pressure balloons, temperature sensors, pressure sensors and precision GPS sensors. Software to support the system components include a real time tracking website, tracking ground station code, dual camera and streaming code, along with the embedded code. Participating teams will learn the systems and have an opportunity to create their own payload.

FE02 (9:40 to 9:50 AM TUESDAY) | High Altitude Balloon Directional Measurements of Cosmic Ray Shower Events

Contributed – Presenting Author: Erick Agrimson, St. Catherine University

Galactic cosmic rays are high-energy particles that impinge on Earth's atmosphere, in the form of positively charged particles, protons. The protons interact with atmospheric nuclei to produce a cascade of secondary particles known as a galactic cosmic ray shower. This post-collision secondary shower depends on altitude, latitude, solar activity, and air pressure. The Regener-Pfotzer (R-P) maximum, which is stated to be between 15-25 km, is the altitude where the maximum number of charged particle detections is measured with a Geiger-Müller detector. In order to better understand the dynamics of the collisions, a flight stack containing two payloads was flown. One payload contained four pancake shaped Geiger counters measuring vertical and horizontal charged particle coincidences. The other payload measured the omnidirectional charge particle interactions. Data show that a R-P maximum occurs at different altitudes depending on direction of the coincidences consistent with previous research in this area.

Session FG: PER: Student Content Understanding, Problem-Solving and Reasoning II

Location: CC: Grand Gallery E **Sponsor:** Committee on Research in Physics Education
Time: 9:10–10:10 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

FG01 (9:10 to 9:20 AM TUESDAY) Learning Vectors Online: Comparing Multiple-Choice to Drawing Vectors

Contributed – Presenting Author: Michael Kline, The Ohio State University

Additional Author | Andrew Heckler, The Ohio State University

We investigated how the answer format for online practice affects the learning and assessment of vector addition skills in introductory university physics. Both algebra-based and calculus-based students practiced vector addition throughout their introductory mechanics course using an online testing and mastery practice platform at a large public university. Class sections were split into two training conditions where students either answer in multiple-choice format or free-response format by drawing the answer vector on a grid. We compared pre- and post-tests between the two conditions to determine whether the vector addition format affected performance and training. On the pretest, there were within-student differences in answering and a hierarchy between question types, where almost all the students who can answer the free-response questions correctly can also answer the multiple-choice questions correctly but not vice versa. We will also present the results from the post-test and any implications for instruction.

FG02 (9:20 to 9:30 AM TUESDAY) Teaching Reasoning Skills Necessary to Validate or Reject a Response*

Contributed – Presenting Author: Mila Kryjevskaia, NDSU

Additional Author | Safana Ismael , North Dakota State University

Research suggests that certain incorrect patterns of student reasoning remain even after instruction. Many challenging tasks seem to elicit strong intuitively appealing (but incorrect) responses. Even those students who demonstrate that they possess the formal knowledge necessary to analyze given situations correctly tend not to use this knowledge. Dual-process theories of reasoning suggest that to catch a mistake, (1) a reasoning red flag must be raised, and (2) the validity of a response must be checked. The last step is particularly challenging for many introductory physics students. In this talk, we will discuss the results of a study intended to help students develop validity checking strategies in various situations that require the application of Newton's second law. We will discuss implications for instruction and research.

*This material is based upon 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

FG03 (9:30 to 9:40 AM TUESDAY) Using 3D-printed Models to Help Students to Draw Free-Body Diagrams

Contributed – Presenting Author: Promail K.Y. Leung, The University of Hong Kong

Teaching and learning in physics have long been challenging because the subject involves numerous abstract concepts that require multidimensional higher-order thinking skills. Take free-body diagrams (FBDs) as an example: in drawing them, students need to construct an accurate FBD (with the correct magnitude, direction, and location of force vectors) to represent their conceptual understanding of vectors and motion to calculate the unknown variables. Studies show that many students struggle with vector concepts and misconceptions when drawing FBDs even when such e-learning tools as simulations are available, and the steps for drawing FBDs are suggested. This paper describes a tangible three-dimensional-printed (3D-printed) FBD model that can help students visualize the relationship among force vectors. The proposed 3D-printed FBD model was piloted in a Grade 10 class with 16 students in a Hong Kong secondary school. Analysis of the students' FBD drawing performance before and after the model's introduction revealed observable improvements.

FG04 (9:40 to 9:50 PM TUESEDAY) Improving Student Understanding of Static Equilibrium with an Interactive Tutorial*

Contributed – Presenting Author: Alexandru Maries, University of Cincinnati

Additional Author | Kathleen Koenig, University of Cincinnati

Additional Author | Ryan Massie, University of Cincinnati

Additional Author | Robert Teese, University of Cincinnati

Under NSF funding, in the past few years, we have been developing Interactive Video-Enhanced Tutorials (IVETs) designed to help students learn effective problem-solving strategies. The IVETs, which incorporate multimedia learning principles, are adaptive and guide students through an expert-like problem solving strategy while providing different levels of feedback and guidance for different students. They also adapt to students' affect by providing additional guidance to students who indicate they are confused, frustrated, or bored while completing the IVETs. This presentation will showcase our IVET on Static equilibrium and present results from implementing it in a large-enrollment calculus-based course.

*Work supported by the NSF IUSE Program (DUE #1821396)

FG05 (9:50 to 10:00 AM TUESDAY) Algebra Accuracy and Response Time: Physics vs Common Math Symbols

Contributed – Presenting Author: Harish Moni Prakash, Ohio State University

Additional Author | Andrew F Heckler, Ohio State University

We report on a study of response time data on basic algebra questions in undergraduate introductory Physics courses to learn more about its relationship with accuracy. Of specific interest is the importance of familiarity with Physics symbols in algebraic expressions. For isomorphic questions, we investigate the differences in response time and accuracy distributions between two groups of students - one trained with common Math symbols and the other with Physics symbols. We also investigate and compare changes in the response time-accuracy relation for the two symbol formats. To improve the analysis, a response time effort index is created based on the distributions to estimate the number of students making rapid guesses. Important goals of this analysis include gaining insights into how to construct valid and reliable measures of algebra skills relevant for introductory physics, and the extent to which students can improve these skills on time scales of weeks.

Session FH: PER: Assessment, Grading and Feedback II

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Research in Physics Education

Time: 9:10–10:10 a.m. **Date:** Tuesday, July 12 **Presider:** TBA

FH01 (9:10 to 9:20 AM TUESDAY) Using IBM's Watson as a Tool for Student Short-Answer Analysis*

Contributed – Presenting Author: Jennifer Campbell, University of Illinois Urbana-Champaign

Additional Author | Katie Ansell, University of Illinois Urbana-Champaign

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

Recent advancements in natural language processing (NLP) have generated interest in using these kinds of software to assist in the coding and analysis of students' short answer responses for either research or a classroom setting. We train a state-of-the-art NLP, IBM's Watson, and test its agreement with humans in three varying experimental cases. Watson was not able to match the interrater reliability of humans (.68 vs .8). However, Watson's self-reported confidence for a given rating was well-aligned with its accuracy. We will discuss these results and their implications for two types of situations: high-stakes for research purposes, where humans code alongside Watson starting with samples for which it has lowest confidence until consistent agreement is reached; and low-stakes for large-enrollment class diagnostics, where Watson can code all statements by itself, as the required level of accuracy is not as high.

*This work was partially supported by a grant from the National Science Foundation NSF DUE 2021099

FH02 (9:20 to 9:30 AM TUESDAY) The Pandemic and Introductory Mechanics Course Learning Outcomes

Contributed – Presenting Author: Matthew Fairbanks, California State University Maritime Academy

The COVID-19 pandemic has and will continue to deeply affect our world, and its effects on student learning, both in physics and more generally, are likely to be profound for many students. Faculty at CSU Maritime Academy have anecdotally reported the average level of student preparedness among freshman is noticeably reduced. This study examines student learning outcomes in algebra-based, Newtonian mechanics courses pre-pandemic, during pandemic, and "post"-pandemic using the Force Concept Inventory and course-specific assessments. CSU Maritime Academy is a small university, which means that the number of students involved in this data set is small but will form the basis for further, broader studies. The author anticipates that this study can inform how best to allocate instructional and student support for students whose late high school and early college education was affected by the pandemic.

FH03 (9:30 to 9:40 AM TUESDAY) Study Habits of College-Bound High School Physics Students*

Contributed – Presenting Author: Devyn Shafer, University of Illinois Urbana-Champaign

Additional Author | Daniela Girotti, University of Illinois Urbana-Champaign

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

In this talk, we will share what we have learned about the study habits and support structures used by students enrolled in standard, honors, IB, and AP physics courses in high school. Data has been collected from two complementary sources: semi-structured interviews with five high school seniors planning to attend college for engineering and written survey responses from 87 students enrolled in introductory mechanics for physics and engineering majors at a large, public research university. Students described what they saw as their most effective practices as well as the types of support provided by their instructors. We have analyzed the data through a lens of student preparation for success in college. Understanding existing student habits and resource use can help high school and college instructors alike to advise students for effective study outside of class.

*This work was supported by NSF DRL 20-10188 and NSF DUE 2021099.

FH04 (9:40 to 9:50 AM TUESDAY) Changes in Student Study Strategies from High School to College*

Contributed – Presenting Author: Daniela Girotti-Hernandez, University of Illinois

Additional Author | Devyn Shafer, University of Illinois

Additional Author | Tim Stelzer, University of Illinois

The transition from high school to college is challenging for many students. From differences in teaching styles to changes in support systems, students may find they need to modify their study strategies for academic success. Previous interviews revealed that difficulty constructing support networks in the first year of college and

discomfort with reaching out to instructors and classmates for help can hinder student success. In this presentation, we provide results from surveys of students in a first-year calculus-based physics course. In addition to the entire class self-reporting the significance of the changes to how they study, we have detailed responses from a representative subset of students who completed a more extensive survey after each of the three midterm exams. We find significant variation in the student responses and look at correlations between their responses and their exam performance.

*This work was supported by NSF DUE 2021099.

FH05 (9:50 to 10:00 AM TUESDAY) Developing the Key Organizational Components Model for Informal Physics Programs

Contributed – Presenting Author: Dena Izadi, Michigan State University

Additional Author | Bryan Stanley, Michigan State University

Additional Author | Claudia Fracchiolla, American Physical Society (APS), University College Dublin

Additional Author | Kathleen Hinko, Michigan State University

Informal physics programs, also known as outreach, are understudied partly due to the broad spectrum of program structures and wide variety of activities. Moreover, the program leaders and facilitators come from a diverse background; faculty members at universities, staff members of science museums, students and practitioners. In this study, we conduct an in-depth analysis of surveys and interviews from a diverse subset of our national data set. Our goal is to develop and validate a model for the key organizational components of informal physics programs. Throughout this process, we adopted The Physics Teacher Education Program Analysis (PTEPA) Rubric approach, designed to provide strategies for program assessment in formal education. In our current model, we have identified 11 categories of organizational components that demonstrate the inner workings of the studied programs. In this talk, we present our model and discuss the future work to develop tools for effective program assessment.

FH06 (10:00 to 10:10 AM TUESDAY) Supporting Instructors through Research Based Assessment

Contributed – Presenting Author: James Laverty, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | Alexander Adamson, Kansas State University

Additional Author | Josh Weaver, Kansas State University

Additional Author | Bethany R Wilcox, Kansas State University

Research based assessments have a productive and storied history in PER. While useful for conducting research on student learning, their utility is limited for instructors interested in improving their courses. We have developed a new assessment design process that leverages three-dimensional learning, evidence-centered design, and self-regulated learning to deliver actionable feedback to instructors about supporting their students' learning. We are using this approach to design the Thermal and Statistical Physics Assessment (TaSPA), which also allows instructors to choose learning goals that align with their teaching. Perhaps more importantly, this system will be completely automated when it is completed, making the assessment scalable with minimal burden on instructors and researchers. This work represents an advancement in how we assess physics learning at a large scale and how the PER community can better support physics instructors and students.

PLENARY II: *Wendy Adams*

Wendy Adams

Wendy is a Research Associate Professor at the Colorado School of Mines with over 15 years of teaching from introductory physics to graduate-level science education research seminars. Her research focuses on formative assessment and curriculum design. Wendy developed the widely used CLASS, which measures students' perceptions of physics and how to learn physics. She has also completed extensive work on problem-solving evaluation and developed the interface design guidelines for the PhET Interactive Simulations. Wendy recently developed the PTaP (Perceptions of Teaching as a Profession) instrument. She also designed and developed several curricula, including the (Explore Sound project – K14) materials for acoustics.

AAPT PHYSICS EDUCATION

Tuesday, July 12

11 a.m.–12 p.m.

Hotel: Ambassador Ballroom

PhysTEC Teacher of Year Award: *David Wirth*

Session GA: Implementing Get the Facts Out Resources Locally & Regionally

Location: CC: Grand Gallery A **Sponsor:** AAPT

Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

GA01 (1:00 to 1:30 PM TUESDAY) Recruiting Teachers: What's that thing you do?

Invited – Presenting Author: Steven Maier, Northwestern Oklahoma State University

If you ask a director of recruitment "What's that thing you do to recruit students?," you'll likely get an awkward look. It would be a look similar to the one you would give them if they asked you "What do you teach your majors?" The truth is, effective recruiting requires a strategy, multiple actions, sustained effort, and mindful messaging to effectively market your program. This is especially true for teacher preparation programs because the recruitment efforts need to include marketing the profession itself, not just the discipline that hosts the major. And some marketing will need to be directed toward fellow faculty. Fortunately, Get the Facts Out has vetted resources to help departments tailor media/content to best meet those needs. From presentations, posters, and postcards to shared Google sheets, LFD slides, and mass mailings, I will share my experiences making use of these resources in my local context.

GA02 (1:30 to 2:00 PM TUESDAY) 700 Student Study: Increased Desire to Become a Teacher

Invited – Presenting Author: Lucia Grande, Colorado School of Mines

Additional Author | Jared B. Breakall, Snow College

Additional Author | David May, Colorado School of Mines

Additional Author | Wendy K. Adams, Colorado School of Mines

In this presentation recent results from the Get the Facts Out project will be shared. In particular, exciting results from a large-scale study of incoming freshman at the Colorado School of Mines has demonstrated striking shifts in students' desire to become a teacher. To better understand the impact of the Get the Facts Out resources on students' career interests, we developed a controlled study that involved over half of the incoming class at the Colorado School of Mines. Specifically, we measured the impact of the Busting Myths About the Teaching Profession presentation on student perceptions as measured by both the internal presentation pre/post survey and the PTaP Instrument. Immediately after the presentation over 40% of the students shifted to a more positive response on the statement "I want to become a grade 7-12 teacher". Two months later this shift persisted for a large fraction of these students. NSF #1821710

GA03 (2:00 to 2:10 PM TUESDAY) Strengthening High School Teacher Quality Through a University Partnership

Contributed – Presenting Author: Marianna Ruggerio, Auburn High School

In 2020 the University of Illinois launched The Illinois Physics and Secondary Schools (IPaSS) Partnership Program with goals specifically related to increased student interest in STEM in physics through intensive teacher support. The partnership provides teachers with research based resources from the University for classroom use. As a result of pulling together teachers from across the state, the partnership has also created a strong network of emerging teacher-leaders in physics classrooms and the quality of physics instruction is increasing for all participants. This talk will discuss the influence and benefits of the program from the teacher perspective.

GA04 (2:10 to 2:20 PM TUESDAY) Teachers Quit at Lower Rates than Most Other Professionals

Contributed – Presenting Author: David May, Colorado School of Mines

Additional Author | Drew Isola, Get the Facts Out

Additional Author | Wendy Adams, Colorado School of Mines

We investigated the effect of the pandemic on teacher quit rates using public records from the U.S. Dept. of Labor. Over the past 20 years, people employed by public educational institutions (the vast majority of whom are K-12 teachers) voluntarily left their jobs at a lower rate than nearly all other groups. During the pandemic, teacher quit rates did not change significantly, while the quit rates for most other occupation groups rose sharply during 2021. This finding brings up questions about how teachers have been impacted by the pandemic relative to other professionals and has implications for how we talk with students and others about career choices.

Session GB: Make, Play, Do and Learn

Location: CC: Grand Gallery Overlook E **Sponsor:** AAPT

Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** Nina Morley Daye

Do you have a low cost, easy to make item that uses readily available materials? Do you want to support K-12 education? Create a document or item you are sharing during this session. Include the materials needed, the instructions to make the item, a picture of a completed item and links to the NGSS in your document. (If you don't know what the NGSS are, please contact your local PTRA or Mark Hannum at the AAPT office.) Please bring materials with you for others to use to make your item and be available to support the people who come by your table.

Session GC: PER: Diversity, Equity & Inclusion II

Location: CC: Grand Gallery C **Sponsor:** Committee on Research in Physics Education

Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

GC01 (1:00 to 1:10 PM TUESDAY) Positioning and Intersectionality in an Inquiry-based Undergraduate Physics Lab

Contributed – Presenting Author: Mark Akubo, Cornell University

Additional Author | Meagan Sundstrom, Cornell University

Additional Author | Natasha G Holmes, Cornell University

Research suggests that there are differences across gender and race in the roles students take on during small group work in undergraduate physics labs. Very little work, however, has looked at the intersectionality of gender and race in these contexts. Here we employ positioning theory and intersectionality theory to analyze discourses in a diverse (racially and gender) group of three students in an introductory physics lab. We seek to identify and describe the roles that the participants engaged in and understand how these roles translate into positioning. In pursuing these descriptive goals, we examine the relationship between one groupmember's intersectional identity (Black Woman) and the group dynamics that may explain how the students positioned themselves and each other during knowledge- construction. Our analysis demonstrates that using intersectionality theory leads to different interpretations of the group positioning than if we were to consider race or gender separately.

GC02 (1:10 to 1:20 PM TUESDAY) Examining Factors Related to Rural, First-Generation Student Persistence in STEM

Contributed – Presenting Author: Elaine Christman, West Virginia University

Additional Author | John C. Stewart, West Virginia University

This study applied survival analysis to explore outcomes of students pursuing STEM majors at a large, eastern, land-grant university. Students who attended high school in rural locales and those who were first-generation college students displayed qualitatively different patterns of changing majors and of departing the university than did continuing-generation, non-rural students. This suggests that the most crucial points in the college career to provide support or encouragement to make the decision to continue may also differ. Logistic regression was used to examine factors, including high school preparation and college course-taking patterns, that correlate with persistence and successful progress in STEM majors.

GC03 (1:20 to 1:30 PM TUESDAY) International Graduate Student Perspectives and Implications for Physics Departments

Contributed – Presenting Author: Miguel Rodriguez, University of Utah

Additional Author | Mirna Mohamed, University of Utah

Additional Author | Ramon Barthelemy, University of Utah

International scholars account for about half of the students in graduate physics programs and over a third of all graduate STEM programs in the United States. International scholars face barriers associated with being an immigrant and discrimination for also often being People of Color, on top of the challenges associated with their graduate programs. In this work, we asked international students in graduate STEM programs about their experiences at their predominantly white institutions. This presentation will focus on the cultural challenges our international participants faced among other social and racial barriers they reported. The experiences of our participants varied by department and demographic representation, with some being isolated and others having culturally similar peers. Using a critical systemic approach, departmental structures were also found to significantly impact our participants. Implications from our findings for physics departments will also be discussed.

GC04 (1:30 to 1:40 PM TUESDAY) The Banking Model of Physics Education

Contributed – Presenting Author: Vanessa Dela Paz Maca, Lafayette College

Typically, physics education research addresses alternatives to transmission-based models of instruction. In light of critical pedagogy, I argue that the more relevant model to address is the banking model of education as identified by Paulo Freire, which subjects students to the colonialist consciousness and obedience to authority. In doing so, we can better identify root structural issues that plague the physics community. I argue that the Western conception of objectivity in science is motivated by the colonialist consciousness. The rigidity of what is considered science limits the identity of scientists to those of European descent, erasing the historical scientific knowledge of other peoples, such as the Indigenous peoples. I demonstrate a framework in which physics education is informed by critical pedagogy, as shaped by bell hooks and Sandy Grande, principled upon respect, reciprocity, and the human experience.

GC05 (1:40 to 1:50 PM TUESDAY) Cultural Beliefs and Systemic Inequity in Astronomy Graduate Programs

Contributed – Presenting Author: Fatima Abdurrahman, University of Maryland, College Park - Department of Physics

Additional Author | Alice R Olmstead, Texas State University - Department of Physics

We use the lived experiences of 12 female and gender nonconforming students of color to construct a model outlining how physics and astronomy graduate programs in American Predominantly White Institutions maintain equity gaps between majoritized and minoritized students. This model connects participant's observations of attitudes, policies, and behaviors to two foundational cultural beliefs in Western physics and astronomy: 1)

academic departments function as meritocracies where only the fittest survive, and 2) physicists comprise an objective, cultureless, and apolitical community, impervious to social influence. We also identify commonalities between the negative outcomes study participants report and outcomes for minoritized students that have been documented in prior literature, such as alienation from their departments, mental health problems, and lower retention in the field. In outlining this system, we emphasize the design of programs as a critical point of intervention. To this end, we conclude the work with recommendations based on participant input.

GC05 (1:50 to 2:00 PM TUESDAY) Encouraging a Growth Mindset

Contributed – Presenting Author: Chuck Winrich, Babson College

Many students approach classes with a fixed mindset; they believe they are either good or not good in a particular subject. This can be reinforced in college courses where students come with a variety of backgrounds from high school. A growth mindset has been linked to higher motivation and enjoyment of learning as well as higher achievement. In this talk, I will present three 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 in the projects and student feedback gathered from course surveys.

GC06 (2:00 to 2:10 PM TUESDAY) Developing Belonging and Purpose in Introductory Courses for Non-Majors

Contributed – Presenting Author: Jonathan Perry, University of Texas at Austin

Students entering into their first physics class can often feel nervous about the impacts of failure and may overly focus on the outcomes of assignments as opposed to the deeper learning of the materials. Here, the structure and impact of two small interventions, developed in collaboration with the Texas Mindset Initiative, are discussed. The first addresses developing sense of belonging through stories shared with students to normalize adversity in the classroom. The second addresses developing purpose around class activities and assessments through intentional communication and pro-social writing activities in the classroom. The goal of these activities is to help students better understand why and how to guide and gauge their learning. Impacts of these interventions will be discussed through changes to student behavior and results from a survey which probed constructs including trust and fairness, institutional growth mindset, and social belonging.

Session GD: PER: Student Content Understanding, Problem-Solving and Reasoning III

Location: CC: Grand Gallery B **Sponsor:** AAPT
Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

GD01 (1:00 to 1:10 PM TUESDAY) Pragmatic and Epistemic Agency in a Project-based Computational Physics Course

Contributed – Presenting Author: Anna Phillips, Tufts University

Presenting Author | Timothy Atherton, Tufts University

Additional Author | Ezra Gouvea, Tufts University

Additional Author | Hugo Beauchemin, Tufts University

Additional Author | Brian Gravel, Tufts University

Epistemic agency, or agency over knowledge, is well-studied in K-12 STEM learning environments and an area of current research within university physics laboratories. However, it has not been explored in upper division and major courses. In this talk, we explore how students engage in practices mirroring those of professional physicists in a project-based computational physics course designed to support students' epistemic agency. We introduce the overlapping yet distinct concept of pragmatic agency, or agency over practical decisions, to understand how students work evolves. We focus on a project where they also engage in making: they build physical and computational models in parallel. We argue for the importance of students having extensive agency over what to model and how to model for developing a grasp of computational physics practice.

GD02 (1:10 to 1:20 PM TUESDAY) Student-Constructed Eigenvalue Equations in Quantum Mechanics: A Symbolic Forms Analysis*

Contributed – Presenting Author: Anthony Pina, University of Maine

Additional Author | Zeynep Topdemir, University of Maine

Additional Author | John R Thompson, University of Maine

As part of an effort to examine students' mathematical sensemaking in a spins-first quantum mechanics course, students were asked to construct an eigenvalue equation for an operator that represents the position of a particle constrained to exist along a line. A subset of student responses took the general form of an eigenvalue equation written in Dirac notation. These responses were indicative of a few different ways of thinking about eigenvalue equations: a standard geometric interpretation, operating as measuring, and the eigenvalue equation as it relates to potential outcomes of measurement. In the context of Sherin's symbolic forms framework, these data suggest three different symbolic forms for an eigenvalue equation that all share a single symbol template but have different conceptual schemata.

*This Material is based upon work supported by the National Science Foundation under Grant No. PHY-1912087.

GD03 (1:30 to 1:40 PM TUESDAY) Network Analysis of Student Interpretations of Dirac Expressions Across Curricula

Contributed – Presenting Author: William Riihiluoma, University of Maine

Additional Author | Zeynep Topdemir, University of Maine

Additional Author | John R Thompson, University of Maine

One important outcome of physics instruction is for students to be capable of relating physical concepts to multiple mathematical representations. In quantum mechanics (QM), students are asked to work across multiple symbolic notations, including some not encountered in previous coursework. To investigate student understanding of the relationships between expressions used in these various notations and generic vector expressions, a survey was distributed to students in upper-division QM courses at multiple institutions. The courses surveyed included those structured both as "spins-first" and "wave functions-first." Network analysis techniques were used to compare student understanding of common expressions used in these courses, in both Dirac notation and wave function notation. Preliminary analysis suggests that, in addition to more distinct morphological grouping, students in "spins-first" courses also appear to conceptualize Dirac expressions as more vector-like than those in "wave-functions first" courses, consistent with the instructional emphasis.

*This Material is based upon work supported by the National Science Foundation under Grant No. PHY-1912087.

GD04 (1:40 to 1:50 PM TUESDAY) Assessing Thinking Skills in Free-response Exam Problems: Covid vs. Non-covid

Contributed – Presenting Author: Fatema Al Salmani, Texas Tech University

Additional Author | Beth Thacker, Texas Tech University

Additional Author | Jordan Johnson, Texas Tech University

We designed a rubric to assess free-response exam problems in order to compare thinking skills evidenced in exams in classes taught by different pedagogies. The rubric was designed based on Bloom's taxonomy (revised version) [1-3]. It was then used to code exam problems. We are now using this rubric to analyze the thinking skills of students taught online during covid vs. students taught in class after covid. We analyzed exams from different sections of the algebra-based physics course taught online during covid and in class after covid. We discuss the instrument, present results and future research plans.

GD05 (1:50 to 2:00 PM TUESDAY) How Students Compare and Contrast the "Discreteness" of Quantum Representations

Contributed – Presenting Author: Christian Solorio, Oregon State University

Additional Author | Elizabeth Gire, Oregon State University

Additional Author | David Roundy, Oregon State University

Quantum mechanics is increasingly being taught "spins-first": using systems with spin as examples before systems with wave functions. It is important for spins-first instructors to understand how students apply knowledge from spin systems to understand the continuous quantum systems that they study later. We are studying the ideas that students have about discrete bases, continuous bases, and the connections between them. We interviewed six students who were enrolled in a spins-first quantum mechanics course and asked them to participate in a card-sorting task where they organized twenty cards with a variety of quantum mechanics content and representations including braket notation, matrix notation, function notation, and code snippets. In this talk, we will discuss the reasoning participants used to organize cards into "discrete" and "continuous" categories as well as how students described the different types of representations as communicating "discreteness".

GD06 (2:00 to 2:10 PM TUESDAY) Using Metacognitive Prompts to Explore Student Reasoning Trajectories*

Contributed – Presenting Author: Em Sowles, University of Maine

Additional Author | Drew J Rosen, University of Maine

Additional Author | MacKenzie R Stetzer, University of Maine

Previous research has shown that students who demonstrate sufficient skills and conceptual understanding to reason productively may perform inconsistently on analogous questions. Such inconsistencies can be explained via dual process theories of reasoning (DPToR). To gain insight into students' reasoning trajectories, we developed an exploratory sequence of DPToR-aligned metacognitive prompts and administered the sequence immediately after students answered a physics question containing salient distracting features. The metacognitive prompts asked students to reflect on their initial ideas, the extent to which they had doubts about those ideas, the extent to which their final answer differed from those ideas, the nature of their reasoning approach, and their confidence in their own understanding. In this talk, we describe how we use student responses to these prompts, along with timing data and a measure of cognitive reflection skills, to investigate students' reasoning trajectories.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

Session GE: PICUP Capstone Conference Report

Location: CC: Grand Gallery E **Sponsor:** Committee on Educational Technologies

Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** Brandon Lunk

GE01 (1:00 to 1:30 PM TUESDAY) Exercise Sets, Faculty Commons, and Resources of the PICUP Website

Invited – Presenting Author: Todd Zimmerman, University of Wisconsin - Stout

Over the past several years, the Partnership for Integrating Computation into Undergraduate Physics (PICUP) has curated a collection of materials to help instructors add in computational modeling to their courses. I'll discuss the various resources and how you can contribute to the community.

GE02 (1:30 to 2:00 PM TUESDAY) Success and Remaining Challenges for PICUP and Integrating Computation

Invited – Presenting Author: Alexis Knaub, AAPT

The Partnership for the Integration of Computation into Undergraduate Physics (PICUP) has had numerous successes since its beginning. However, challenges do remain as change is a slow process. This talk, by the external evaluator for PICUP, provides an overview of the summative evaluation featured in the PICUP Capstone Conference Report. Potential future avenues are also discussed.

Session GF: Pulsars and Radio Astronomy

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Space Science and Astronomy
Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** Ann Schmiedekamp

GF01 (1:00 to 1:30 PM TUESDAY) Simplifying Pulsar Timing Array Science for Students

Invited – Presenting Author: Michael Lam, Rochester Institute of Technology

The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) collaboration is working towards the detection and study of low-frequency gravitational waves using an array of rapidly rotating, highly stable radio pulsars distributed across the galaxy as accurate and precise clocks. A significant amount of research is driven by students from the high school to the graduate level. Students new to the field find themselves engaging with a large cross-section of many fields of astronomy, learning about stellar evolution, compact objects, galaxy evolution, gravitational waves, the interstellar medium, and more, and we strive to make our science accessible to them. I will describe our research program and specifically highlight the efforts within the collaboration to make our science more accessible to new students at many levels, getting them involved in cutting-edge science as quickly and easily as possible.

GF02 (1:30 to 2:00 PM TUESDAY) Pulsars – The Story of the Stellar Clocks in the Sky

Invited – Presenting Author: Natalia Lewandowska, Swarthmore College

Pulsars were discovered in 1967 and quickly identified as highly magnetized, fast rotating neutron stars. They are remnants of the explosion of a star known as a supernova. A neutron star has a diameter of about 7 miles and about twice as much mass as our Sun. Pulsars spin several times per second and have a magnetic field that can be a trillion times stronger than the one on Earth. As they age they emit electromagnetic radiation ranging from radio waves, visible light possibly up to gamma-rays. Their rotation causes their emission to be received in the form of pulses on Earth. The regularity of these pulses is the reason why they are often referred to as clocks in the sky. Some of them are more regular than others.

GF03 (2:00 to 2:10 PM TUESDAY) Radio Astronomy Research Experiences for Undergraduates

Contributed – Presenting Author: Carl Schmiedekamp, Penn State Abington

Most science and engineering degrees at Penn State require that our students transfer to a different campus to complete their degree, so we have targeted first and second-year students and students with non-science majors. We try to provide a meaningful research experience without overwhelming them.
The Green Bank Observatory (GBO) has dedicated two smaller telescopes for educational use. Our students have recently studied giant pulses from the Crab pulsar (PSR J0534-3300) and the Vela pulsar (PSR J0835-4510) using the GBO 20-meter telescope remotely. Giant pulses are rare, exceptionally large radio pulses and have only been detected in a small number of pulsars. Interactive Jupyter notebooks were developed to process the telescope data. Text files, produced by the notebooks, listing the detected giant pulses, are downloaded to students' laptops and analyzed using spreadsheet programs.

GF04 (2:10 to 2:20 PM TUESDAY) Radio Astronomy Instrumentation and Analysis in Undergraduate Physics

Contributed Presenting Author: Nicole Gugliucci, Saint Anselm College

Additional Author | Seth Adams, Saint Anselm College

Additional Author | Carl Zent, Saint Anselm College

The radio sky is accessible at low cost with the RadioJOVE Project, a dual-dipole with receiver that is used by educators, students, and amateur radio astronomers to detect solar flares and radio bursts from Jupiter. The RadioJOVE has been used at Saint Anselm College primarily for a high school afterschool program, but recently, more sophisticated work on data analysis has been undertaken by undergraduates in the physics department. We will share results from current projects, such as progress towards interference reduction and measuring the signal from the Milky Way, and plans for future work that are appropriate for physics undergraduates who may be new to astronomy.

Session GG: Student Topical Discussion and Social

Location: CC: Grand Gallery Overlook C/D **Sponsor:** AAPT
Time: 1–2 p.m. **Date:** Tuesday, July 12 **Presider:** Stephanie Williams

This session is the primary opportunity for student members of the PER community to meet and discuss common issues. While this session is aimed toward graduate students, we welcome undergraduates who are interested in studying PER or curious about life as a graduate student!

AWARDS

David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching: Sean Bentley

Sean Bentley

Some Pain, Much Gain

To say the past two years were challenging would be an obvious understatement. However, it did force us to evaluate alternative educational approaches, with extra hurdles for a science based in experimentation and laboratory instruction. Instructional changes always pose difficulties, from overcoming departmental inertia and faculty resistance to building student buy-in and engagement in unfamiliar learning experiences. The proven gains in student learning, though, are well worth the initial pains. I will explore a few recent examples of such changes we have implemented in our department, from introductory labs to senior courses, focusing on strategies for overcoming the challenges.

AAPT PHYSICS EDUCATION

Tuesday, July 12

2:30–3:50 p.m.

Hotel: Ambassador Ballroom

Paul W. Zitzewitz Excellence in K-12 Teaching Award: Andres R. Torres

Andres R. Torres

Thoughts on Teaching and Motivating Students While Implementing a StepUp for Physics Curriculum

For many years as a physics teacher, I always wondered how we could increase the number of women studying STEM careers. Research has shown that there has been a massive improvement for women in medicine, business, and law careers over the past few decades (Silva, 2019). After completing a curriculum with interdisciplinary lessons and extracurricular activities, I knew that Physics teachers are highly effective in motivating students to show interest in physics principles and applications in their daily lives. But in addition to this, Physics teachers could teach lessons to create cultural change and inspire young women to pursue physics in college. STEP UP is a national community of Physics teachers that provides valuable lessons, strategies, and professional developments (Step Up Physics Together, n.d.). Implementing the STEP UP curriculum in my classes and creating STEP UP for the physics club were successfully inspirational in motivating underrepresented students to pursue Physics and STEM careers. Class discussions, club presentations to middle schools in the community, and parents' participation in extracurricular activities were extremally valuable in improving students' passion for Physics and recognizing themselves as Physics individuals.

Works cited

Silva, V. (2019, April 29). *4 Main Reasons Why There Is a Lack of Women in STEM.* Retrieved from Build By Me: https://www.builtbyme.com/lack-of-women-in-stem-reasons

Step Up Physics Together. (n.d.). Retrieved from Engage: https://engage.aps.org/stepup/home

AAPT Distinguished Service Citations and AAPT Fellows

Distinguished Service Citation:

Paula Heron, University of Washington, Seattle, WA

AAPT Fellows:

Geraldine Cochran, Rutgers University, Piscataway, NJ

Laura McCullough, University of Wisconsin-Stout, Menomonie, WI

Arlisa Richardson, Chandler Gilbert Community College, Gilbert, AZ

Session HA: Chaotic Laboratories and Apparatus

Location: CC: Grand Gallery A **Sponsor:** Committee on Apparatus
Time: 4–5 p.m. **Date:** Tuesday, July 12 **Presider:** Paul Noel

HA01 (4:00 to 4:10 PM TUESDAY) Exploring Chaos by Creating Simulations of Nonlinear Systems

Contributed – Presenting Author: Craig Wiegert, University of Georgia

As a capstone project in an upper-level undergraduate classical mechanics course, students were asked to choose a nonlinear system and create a computational model to investigate conditions under which the system might exhibit chaotic behavior. I'll discuss some of the systems that students could choose to investigate, describe the steps in their modeling process, and show a few examples of the presentations students created. Their computational models could easily be adapted into apparatus simulations for the purposes of taking and analyzing data.

HA02 (4:10 to 4:20 PM TUESDAY) Semiclassical Mastermind

Contributed – Presenting Author: Joshua Qualls

Presenting Author | Joshua D Qualls, Morehead State University

Games are often used in the classroom to teach mathematical and physical concepts. Yet the available activities used to introduce quantum mechanics are often overwhelming even to upper-level students. Further, the "games" in question range in focus and complexity from superficial introductions to games where quantum strategies result in decidedly nonclassical advantages. In this talk we introduce a straightforward newly-developed "Semiclassical Mastermind" based on replacing colored pegs in the popular board game with possible orientations of four qubits. Due to superposition and collapse, the game becomes probabilistic and requires repeated measurements to determine the states in the "solution". We report on the mathematical analysis of three strategies for play and conclude by previewing how a "quantum" player could potentially outperform even optimal "classical" players.

HA03 (4:20 to 4:30 PM TUESDAY) Student Built Remote Chaotic Pendulums

Contributed – Presenting Author: Lauren Dana, Worcester Polytechnic Institute

During the chaotic transition to remote labs we developed a 'chaotic pendulum' lab for remote students for our oscillations and waves class. This involved students building their own double pendulum at home, recording its oscillations, and analyzing those movements. The first time we ran it, it did not work. We have since then iterated upon that initial design, and are happy to present something that is suitable for advanced, experimentally motivated remote students using resources commonly available at home and the free video analysis software Tracker.

Session HB: Introductory Courses I

Location: CC: Grand Gallery B **Sponsor:** AAPT
Time: 4–5 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

HB01 (4:00 to 4:10 PM TUESDAY) Lessons Learned from Teaching a Physics Sequence with Contract Grading

Contributed – Presenting Author: Jon Gaffney, Utica University

For the academic year 2021-2022, I designed and created a two-semester algebra-based physics sequence specifically for students enrolled in the construction management program at Utica University. This course met for 115 minutes a day, 3 days a week in a studio-style physics classroom. The course sequence integrated lectures and lab activities, and students engaged with active-learning methods during class time. Students chose to follow an A, B, or C contract and were graded based on criteria on those contracts. In this talk I will discuss some of the advantages of that grading style, some of the lessons I wish I had learned before starting it, and some unexpected consequences. I will also describe some of the changes I made between the first and second semester course and describe the effectiveness of those changes.

HB02 (4:10 to 4:20 PM TUESDAY) Interviews on Computation in Introductory Physics: Reading Code is Everything!

Contributed – Presenting Author: Justin Gambrell, Drexel University

Additional Author | Eric Brewe, Drexel University

Additional Author | Adam Ikehara, Drexel University

We present a qualitative analysis of twenty-six interviews asking physicists about computational thinking in introductory physics courses. The interviews are part of a longer-term project in developing an assessment protocol for computational thinking in introductory physics. The focus of this presentation is on sub-nodes and themes developed for seven nodes coded from the interviews using emergent coding, constant comparative method, and grounded theory. We find that python/vpython or spreadsheets are the preferred environment, and that students being able to read code, identify the core physics within an environment, explain to others about their code, and use program hygiene (commenting and using meaningful variable names) are the most important skills to be gained. We also find that the experience and skills gained from computation are most useful for student's future careers, and the limiting factors of computation in introductory physics are curricular overhaul, no space for computation, and student/faculty rejection.

HB03 (4:20 to 4:30 PM TUESDAY) Exploring Pseudoscientific Beliefs Among Undergraduate Students

Contributed – Presenting Author: Melanie Good, University of Pittsburgh

Additional Author | Eric S Swanson, University of Pittsburgh

A rationale for requiring undergraduate students to take natural science classes as part of their general education is to promote critical thinking skills and scientific literacy. Belief in pseudoscientific, paranormal, and conspiracy theory claims could be indicative of weaker scientific literacy and critical thinking skills. Thus, uncovering to what degree students subscribe to such beliefs can serve as a diagnostic test of the effectiveness of natural science classes in promoting scientific literacy and critical thinking skills. As a preliminary step in exploring this question, we measured how students enrolled in several introductory level physics and astronomy classes respond to pseudoscientific, paranormal, and conspiracy theory claims, as well as genuine scientific claims at the end of a semester of instruction by administering survey questions from the \textit{Inventory of Epistemically Unwarranted Beliefs} (Dyer \& Hall, 2018). We compare the persistence of these beliefs across classes and to prior results in the literature.

HB04 (4:30 to 4:40 PM TUESDAY) Instrument Projects for Acoustics Students Who Are Non-Science Majors

Contributed – Presenting Author: Ting-Hui Lee, Western Kentucky University

At Western Kentucky University, the students in the introductory acoustics course are about one-third music majors, one-third communication disorders majors, and one-third from other disciplines. Such a diverse group provides an excellent opportunity for collaborative learning. Students from different disciplines are grouped together to build an instrument using common household materials. The instrument must be able to play a simple tune. The students showcase their instruments and explain how they work using the physics of vibration, resonance, pitches, and tone colors. In this talk, I will discuss how these projects engage students, and I will present some of the instruments that the students have made.

HB05 (4:40 to 4:50 PM TUESDAY) Student Resilience: Advantages of a Hybrid NextGen PET Adaptation*

Contributed – Presenting Author: Paul Miller, West Virginia University

Additional Author | Gay Stewart, West Virginia University

Additional Author | Lynnette Michaluk, West Virginia University

The Next Generation Physical Science and Everyday Thinking (NextGen PET) is a proven research-based curriculum that centers the Next Generation Science Standards (NGSS) and has been shown to significantly impact both future teacher content knowledge and understanding of how students learn science. In a recent project*, we developed a hybrid lecture-lab implementation of existing materials and wrote new materials that targeted the NGSS scientific practice of Planning and Conducting Investigations (PCI). Then COVID hit. In this talk, we report on how this recent format change helped us manage the shift online. The students were resilient, based on their course evaluation comments. We examine whether their content learning, attitudes changes, and knowledge of PCI (using materials developed for this purpose) were as resilient with data from before, during, and after the online course. Results of pre-post instruction analyses between groups and evaluation responses are discussed, as are implications for future instruction.

* This work funded in part by the Adapting the Next Generation Physical Science and Everyday Thinking Curriculum for a Lecture-Laboratory Format grant from the NSF, DUE-1611738.

HB06 (4:50 to 5:00 PM TUESDAY) Playing the Marble Game in Excel*

Contributed – Presenting Author: Peter Nelson, Fisk University

The Marble game is a kinetic Monte Carlo simulation of diffusion that introduces students to computation and modeling in a biological context. Ten marbles are distributed between two boxes. The roll of a ten-sided die determines whether a marble jumps from box 1 to box 2 or vice versa. The game can be built using two weigh boats, ten marbles and a ten-sided dice. Once students have learned the rules by playing the game by hand, they implement it in a blank Excel spreadsheet following a guided inquiry methodology. Students plot the number of marbles in box 1 as a function of time for games of different sizes and with various initial conditions and learn how to interpret the data presented in the graphs of their own games. Ultimately, students discover that the random jumping between boxes produces a net flux that's consistent with Fick's laws of diffusion. http://circle4.com/biophysics

*Supported by NSF Grant No. 1817282.

Session HC: Michigan State Physics Research

Location: CC: Grand Gallery F **Sponsor:** AAPT
Time: 4–5:30 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

HC01 (04:00 to 4:30 PM TUESDAY) Nuclear Science for Everyone

Invited – Presenting Author: Zachary Constan, Facility for Rare Isotope Beams

The Facility for Rare Isotope Beams and Joint Institute for Nuclear Astrophysics organize and conduct a host of different outreach programs, all geared to different audiences and goals. Discover the abundance of free resources available to students & teachers, kids & adults in Michigan and anywhere in the world!

HC02 (4:30 to 05:00 PM TUESDAY) Undergraduate Physics Transformations at Michigan State University

Invited – Presenting Author: Stuart Tessmer, Michigan State University

The Michigan State University Department of Physics and Astronomy had the honor of receiving the Improving Undergraduate Physics Education Award this past December. This talk will discuss our efforts and challenges in improving the educational experience for undergraduates, including faculty buy-in, science practices in introductory courses for engineering majors and life science majors, and the integration of computation across the physics curriculum.

HC03 (5:00 to 5:30 PM TUESDAY) Evaluating Patterns Across Educators in their Reflection of Computational Thinking

Invited – Presenting Author: Lillianna Mack, Michigan State University

Additional Author | Paul Irving , Michigan State University

Additional Author | Theo Bott, Michigan State University

Additional Author | Daryl McPadden, Michigan State University

Additional Author | Marcos Caballero

As part of a computational thinking practices survey development process, five secondary educators with experience integrating computation into their physics classrooms were given a fourteen-practice computational thinking framework to reflect on and discuss. The computational thinking framework was presented to the teachers via a 54-question survey which they completed and then discussed in detail. This survey gathered data on which practices were the most important to these teachers, why each teacher felt the practices they chose were the most important, and how the practices were explicitly incorporated into their classroom. Our analysis of this survey shows that there are certain patterns across the educator's interpretation of these practices, as well as overlapping thoughts on the importance of computational thinking in the classroom. This initial data set will be used to iterate on the design of the survey and highlights variation in teachers' priorities related to computational thinking practices.

Session HD: Outreach through Social Media

Location: CC: Grand Gallery C **Sponsor:** AAPT
Time: 4–5:30 p.m. **Date:** Tuesday, July 12 **Presider:** Joseph Kozminski

HD01 (4:00 to 4:30 PM TUESDAY) SciTok, Social Media, and Seeing Science

Invited – Presenting Author: Nora Bailey

Social media is an amalgamation of memes, brunch pictures, personal updates, dance trends—and science? As a communication tool, social media allows scientists to reach audiences where they already are. Seeing scientists in their feed can break stereotypes, introduce new ideas, or ignite lifelong passions for science. Effective science communication via social media can not only educate but also entertain and inspire.

HD02 (4:30 to 5:00 PM TUESDAY) Your Next Great Teaching Idea Is Just a Tweet Away!

Invited – Presenting Author: Andrew Morrison, Joliet Junior College

Social media as we know it now has been around for about 18 years. Because social media platforms make it so easy to broadcast information widely and interact with people having common interests online, vibrant communities of physics instructors have arisen and can be a great way to exchange ideas about all aspects of teaching physics. As a means of broadcasting information and interacting with people online that is nearly two decades old, it would be easy to think that social media is a mature technology by now. I will discuss my observations of using various social media platforms over the span of 14 years and try to speculate about what the next 14 year of social media use might look like.

HD03 (5:00 to 5:10 PM TUESDAY) Physics and Social Media: Everyone's Tok'ing About It

Contributed – Presenting Author: Geoffrey Franceschi, Texas A&M University

Tik Tok has become one of the most popular and influential social media platforms, its content ranges from simple reaction videos to professionally crafted masterpieces, but it lacks in one area; in science education. With the ability to easily reach out to millions of people, it is difficult to ignore the potential that the social media platform offers to get the public more interested in science. By creating short, entertaining and easy to understand videos on physics concepts, my colleagues and I were able to amass over 330,000 followers on Tik Tok. This resulted in a closer relationship with our students, a larger sense of school pride, and an increase interest from the general public to attend our university. Planning, recording, and editing these videos are no easy tasks as one also needs a decent understanding of how Tik Tok's algorithm functions, but it is worth the extra effort.

HD04 (5:10 to 5:20 PM TUESDAY) All Things Physics: A Repository of Video Explorations in Physics

Contributed – Presenting Author: David Jackson, Dickinson College

Compelling narratives have been an important part of human development for thousands of years, and I believe they can provide powerful motivation for students learning physics. With this in mind, I am developing a series of video explorations in physics, each of which makes use of a compelling narrative and focuses on a specific phenomenon in physics. To make these videos as engaging as possible, a cogent storyline is developed that combines lively narration, real-world experiments, and striking graphical animations. The long-term goal is to develop complete sets of videos that correspond to all of the standard courses in the undergraduate physics curriculum. I believe such a repository will be extremely useful to physics students and teachers, as well as the general public. In this talk I will show some sample video clips and describe the challenges I have faced as someone new to social media.

Session HE: PER: Diversity, Equity & Inclusion IV

Location: CC: Grand Gallery E **Sponsor:** Committee on Research in Physics Education
Time: 4–5 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

HE01 (4:00 to 4:10 PM TUESDAY) Moving Beyond 'p<0.05' to Investigate Similarities and Differences

Contributed – Presenting Author: Jayson Nissen, Nissen Education Research and Design

Additional Author | Ben Van Dusen, Iowa State University

Scholars, largely women of color, have used qualitative methods to show the inequities that Black women and other women of color face during their STEM education. Few quantitative discipline based education research studies, however, engage in similar intersectional work. P-values, despite 70 years of constant critique from statisticians, pose a barrier to quantitative researchers engaging in intersectional work. We will discuss recommended statistical practices, how often DBER studies use these practices, and potential solutions for moving beyond 'p<0.05' and engaging in intersectional work.

HE02 (4:10 to 4:20 PM TUESDAY) Why Graduate Students Leave: Exploring Student Perspectives and Experiences

Contributed – Presenting Author: Lindsay Owens, Norco College

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

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

Why do physics graduate students leave their programs? Previous studies report that nearly 40% of physics graduate students do not complete their PhD programs. We conducted semi-structured interviews with 54 graduate students from 23 institutions and asked why physics and astronomy graduate students discontinue their graduate studies. Graduate students cited a variety of cultural and systemic issues that negatively impacted their sense of belonging in the physics community, such as citing unhealthy expectations and hostile environments. In addition, personal non-academic (e.g., health-related) reasons were also frequently mentioned. Finally, a lack of available support structures contributed to students' discontinuing their graduate studies. Understanding the mechanisms behind student departure is the first step in making positive changes to increase retention for all students in physics.

HE03 (4:20 to 4:30 PM TUESDAY) Causal Mapping Analysis of Universal Design for Learning-aligned Instructional Changes

Contributed – Presenting Author: Julia Willison, University of Central Florida

Additional Author | Westley James, Lake Mary High School

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

Additional Author | Jacquelyn J. Chini, University of Central Florida

Universal Design for Learning (UDL) is a framework that supports instructors in designing inclusive learning environments that anticipate and plan for variations in students' needs, abilities, and interests. UDL-aligned instructional design may reduce the need for accommodations for some students with disabilities. In this study, we explore postsecondary physics instructors' approaches to adapting their teaching and learning environment while engaged in a year-long UDL learning community. Revealed causal mapping (RCM) is an analytic technique that uncovers experts' mental maps about their subject domain. We employ RCM to value instructors' knowledge and experiences and identify motivations and goals of the learning community members as they select, implement, and reflect on UDL-aligned modifications to their instruction.

HE04 (4:30 to 4:40 PM TUESDAY) The Scale of it All: Students' Experiences of Spatial Scales

Contributed – Presenting Author: Elias Euler, Lund University

Additional Author | Jenny Sullivan Hellgren, Umeå University

Additional Author | Urban Eriksson, Lund University

This talk reports on the preliminary data and initial findings of a pilot study from a larger project investigating the teaching and learning of spatial/temporal scales in science. We video-recorded pre-service science teachers from physics and biology while completing a ranking task for objects ranging in size from the scale of a proton to the scale of the Universe. From this data, a phenomenographic analysis was carried out to determine the qualitatively different ways in which science students experience spatial scales.

HE05 (4:40 to 4:50 PM TUESDAY) Teaching Ultrasound to Undergraduates Using Project-based Learning Approach

Contributed – Presenting Author: Arbin Thapaliya, Franklin College

Additional Author | Jessica Mahoney, Franklin College

Additional Author | Gaston Dana, Johnson Memorial Hospital

In this talk, we will present about a unique collaboration between a physics faculty, a librarian, and a physician in developing and teaching an ultrasound course in a primarily undergraduate institution. The course followed the Project-Based-Learning (PjBL) approach in which students, by way of argumentation and research, actively and collaboratively engaged in solving real-world and personally meaningful problems. As such, Information Literacy skills were naturally incorporated throughout all of the PjBL projects that students worked on in this course. In preparation for these projects, students learned about basic principles behind ultrasound, as well as the basic operation, controls, and features of an ultrasound equipment. They were also trained to develop ultrasound skills to identify normal anatomy of musculoskeletal, cardiovascular, and abdominal organs and structures. We will present about the opportunities, challenges, and success of this course.

HE06 (4:50 to 5:00 PM TUESDAY) Fostering Group Work in Studio Physics: Developing an Instructor Guide

Contributed – Presenting Author: Mona Peyravi, University of Connecticut, Avery Point

Additional Author | Xian Wu, University of Connecticut, Storrs

Additional Author | Matthew W Guthrie, University of Connecticut, Storrs

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

Previous literature shows that active learning (e.g., group work) supports student learning better when compared with traditional courses. However, many instructors are not trained to foster effective and inclusive group work. To support faculty implementing group work, we created a guide by reviewing literature in three topical domains: cognitive science, research-based instructional strategies, and diversity, equity, and inclusion. We then compiled 29 recommendations for practice aggregated into 6 categories: 1) creating group work activities; 2) creating groups of students; 3) first day framing; 4) supporting students to engage in group work; 5) classroom culture, norms, and practices; and 6) grading group work. We interviewed studio physics instructors to investigate the face validity of the guide. In this talk, we will present the development process of the guide, recommendations from the group work guide, and examples of how the recommendations can be implemented in high school or postsecondary courses.

Session HF: PER: Student Content Understanding, Problem-Solving and Reasoning IV

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Research in Physics Education
Time: 4–5 p.m. **Date:** Tuesday, July 12 **Presider:** TBA

HF01 (4:00 to 4:10 PM TUESDAY) Examining Student Confidence and Calibration in Introductory Physics

Contributed – Presenting Author: Aubrey Sahouria, University of New England

Additional Author | J. Caleb Speirs, University of New England

Some students in an introductory physics course may overestimate their knowledge of a concept, but in reality possess an incomplete or flawed understanding of it. Literature has shown that student conceptions of physics exhibit fragmented understanding without deep understanding. This disconnect is due to deficient calibration, which can be examined by means of a judgment of learning (JOL) - a student rating of how confident one is in their understanding of a concept. Previous studies have found that metacognitive scaffolding increases both conceptual knowledge and confidence judgments of conceptual understanding among students. With this, it is imperative to facilitate students' metacognitive thinking and overall reflection. The present study investigates the accuracy of student JOLs across one semester of an introductory physics course via three content quizzes administered throughout the semester which assessed previously learned concepts, explanations of given answers, and confidence ratings. Results will be discussed.

HF02 (4:10 to 4:20 PM TUESDAY) Insights From an Intervention Designed to Support Consistent Reasoning*

Contributed – Presenting Author: MacKenzie Stetzer, University of Maine

Additional Author | Thomas M Fittswood, University of Maine

Additional Author | Drew J Rosen, University of Maine

An emerging body of research suggests that poor student performance on certain physics questions may stem, at least in part, from the nature of human reasoning itself. While students may demonstrate that they possess the requisite knowledge and skills to reason correctly on one question, they may abandon that same line of reasoning on an analogous question containing a salient distracting feature. As part of a larger effort to investigate and support student reasoning in physics by leveraging dual-process theories of reasoning, we developed and tested an intervention aimed at helping students draw upon the knowledge and skills they already possess to address such reasoning inconsistencies. In this talk, we explore specific factors that appear to be related to student reasoning and how students engage with the intervention.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

HF03 (4:20 to 4:30 PM TUESDAY) Impact of eLearning on NextGen PET Students' NGSS Practice Development*

Presenting Author: Gay Stewart, West Virginia University

Additional Author | Paul Miller, West Virginia University

Additional Author | Lynnette Michaluk, West Virginia University

Additional Author | Rachel Henderson, Michigan State University

Additional Author | Kathleen Koenig, University of Cincinnati

NextGen PET teaching and learning activities are designed to help preservice teachers connect their own learning, the learning and teaching of children in elementary school, and the core ideas, science and engineering practices, and concepts of the Next Generation Science Standards (NGSS). During COVID, instruction in NextGen PET courses moved rapidly online. Recent studies suggest that content knowledge (CK) gains are similar for eLearning and in-person labs, but this has not been studied in NextGen PET courses in which experiential learning is integral to the curriculum. Therefore, this study examined students' pedagogical CK (PCK) of the NGSS practice of Planning and Carrying Out Investigations (PCOI) using materials developed specifically to address and assess PCOI, as well as instructor evaluation responses, for eLearning and in-person Next Gen courses. Results of pre-post instruction analyses between groups for PCOI PCK and evaluation responses are discussed, as are implications for future instruction.

*Part of Adapting the Next Generation Physical Science and Everyday Thinking Curriculum for a Lecture-Laboratory Format, funded in part by NSF DUE-1611738.

HF04 (4:30 to 4:40 PM TUESDAY) "Quantum Weirdness": Physics Paradigm and Student Thinking About Experimental Uncertainty

Contributed – Presenting Author: Emily Stump, Cornell University

Additional Author | Matthew Dew, Cornell University

Additional Author | Gina Passante, California State University Fullerton

Additional Author | N. G. Holmes, Cornell University

Understanding experimental measurement uncertainty is a key learning goal of undergraduate physics laboratory instruction. Most prior research on student thinking about experimental uncertainty has focused on the introductory level, where uncertainty is treated as equivalent to experimental error. Intermediate- and upper-level quantum mechanics courses, however, can further complexify student understanding by introducing a different meaning for measurement uncertainty as an inherent part of the theory of quantum mechanics. We developed a survey to probe students' thinking about the sources of uncertainty in four different experimental contexts involving classical and quantum systems. In this talk I will describe the sources of uncertainty that students identified in classical versus quantum contexts and discuss the instructional implications of these results.

HF05 (4:40 to 4:50 PM TUESDAY) Construction and Evaluation of the Conceptual Survey on Wave Optics

Contributed – Presenting Author: Ana Susac, Department of Applied Physics, Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia

Additional Author | Maja Planinic, Department of Physics, Faculty of Science, University of Zagreb, Croatia

Additional Author | Karolina Matejak Cvenic, Department of Physics, Faculty of Science, University of Zagreb, Croatia

Additional Author | Lana Ivanjek, Faculty of Physics, Physics Education Research, TU Dresden, Germany

Additional Author | Katarina Jelicic, Department of Physics, Faculty of Science, University of Zagreb, Croatia

Wave optics is a challenging topic for high school students, so the aim of our research project is to develop and evaluate an inquiry-based high school teaching sequence on wave optics. Although there are several instruments for measuring university students' conceptual understanding of optics, they are not suitable for application at the high school level. So, we developed a new diagnostic instrument that covers basic concepts of interference, diffraction, and polarization of light. The Conceptual Survey on Wave Optics (CSWO) was constructed and evaluated using the Rasch model. The defined test construct consisted of the increasing levels of cognitive complexity from Webb's Depth of Knowledge framework, and it was confirmed empirically. The final version of the CSWO proved to be a reliable diagnostic instrument that can be used to show the level of student understanding and thus help to improve the teaching and learning of wave optics.

HF06 (4:50 to 5:00 PM TUESDAY) Student Understanding of the Partial Derivatives in Curl and Divergence

Contributed – Presenting Author: Zeynep Topdemir, University of Maine

Additional Author | Michael E. Loverude, California State University, Fullerton

Additional Author | John R. Thompson, University of Maine

As part of an ongoing project to investigate student learning of, and reasoning with, mathematics in upper-division physics, we have examined student understanding of divergence and curl. We developed a series of tasks focusing on graphical interpretations of these quantities as well as their constituent partial derivatives. Written data were collected in Mathematical Methods courses at two universities after students were introduced to vector calculus. When presented with a graphical representation of a vector field, some students seemed to determine the sign of a partial derivative by the change in magnitude of the vector (i.e., arrow length) regardless of direction. Even students who identified the correct signs often did not relate the constituent derivatives to the quantities of divergence and curl.

*This material is based upon work supported by the National Science Foundation under Grant No. PHY-1912087 and PHY-1912660.

Session HG: The International Conference on Women in Physics

Location: CC: Grand Gallery Overlook C/D **Sponsor:** Committee on Women in Physics
Time: 4–5 p.m. **Date:** Tuesday, July 12 **Presider:** Laura McCullough

Panelists will share stories and successes from the recent International Conference on Women in Physics (ICWIP), held virtually in July 2021. These conferences are held every three years and are sponsored by the International Union of Pure and Applied Physics. Delegates from the US were part of poster sessions and workshops, and were able to listen to multiple plenary speakers from around the world. ICWIP draws approximately 200 people, primarily women, from over 60 countries and helps promote women in physics and sharing their struggles and successes.

POSTER SESSION II:

Location: CC: Exhibit Hall C **Sponsor:** AAPT
Time: 9–10:30 p.m. **Date:** Tuesday, July 12

NOTE: Persons with odd-numbered posters will present their posters from 9:00 to 9:45 p.m.; those with even-numbered posters will present from 9:45 to 10:30 p.m. Posters will be available until 10 p.m.

Physics Education Research Posters II

POS2A01 (9:00 to 9:45 PM TUESDAY) Curricular Analytics: The Complexity of Off-Sequence Course Progression

Poster – Presenting Author: John Hansen, West Virginia University

Presenting Author | Amanda Nemeth, West Virginia University

Additional Author | John Stewart, West Virginia University

Heileman et al. developed a methodology for quantifying the complexity of program curricula. In their development, 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. They also show that for students who have to take additional pre-requisites before entering an engineering program - students that are 'off-sequence' - are at a disadvantage to those who enter the program 'on-sequence' due to increased curriculum complexity. Using their methodology and framework, we analyzed the curriculum of different areas of emphasis in physics to compare their complexity. We also investigate the effect on the complexity of a curriculum if a student enters a physics program off-sequence.

POS2A02 (9:45 to 10:30 PM TUESDAY) Developing Actionable Feedback Statements for Research-based Assessments

Poster – Presenting Author: Bethany Wilcox, University of Colorado Boulder

Additional Author | James T. Laverty, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Research-based assessments are ubiquitous within physics education research. These instruments provide a mechanism for instructors and researchers to measure student learning. This, ideally, allows instructors to make informed decisions about their instruction and improve student learning over time. In practice, however, most research-based assessments return only an overall average score and sometimes include breakdowns of scores by item. Faced with these scores, many instructors have difficulty extracting actionable implications for their classroom. To address this disconnect, we are working to develop a process for assessment developers to produce feedback statements in conjunction with their assessments. These statements will focus on articulating the desired outcome, the extent to which the students achieved that outcome, and concrete suggestions for strategies that might improve student performance. Here, we present a concrete example of these feedback statements in the context of thermal physics and solicit input on several versions of the feedback.

POS2A03 (9:00 to 9:45 PM TUESDAY) How Instructor's Conceptions of Knowledge Bolster their Culturally Relevant Teaching

Poster – Presenting Author: Clausell Mathis, University of Washington - Seattle

Additional Author | Abigail R. Daane, South Seattle College

In this study, we examined two current physics instructors' Bruce and Thomas views of objectivity in physics and their views of culturally relevant pedagogy. Their statements were analyzed using the conceptions of Culturally Relevant Pedagogy (CRP) listed in Ladson-Billings' (1995) framework: Conceptions of Self and Others, Conceptions of Knowledge, and Social Relations. Interviews were transcribed and analyzed using thematic analysis. We shared illustrations of their Conceptions of Knowledge that supported CRP that focused on the knowledge of physics as being constructed and reconstructed - now and into the future. Findings from our study indicate that recognition of subjectivity in physics can support instructors in effectively enacting the third conception, Conceptions of Knowledge for optimal use of CRP.

POS2A04 (9:45 to 10:30 PM TUESDAY) Connecting Climate Change to your Energy Unit

Poster – Presenting Author: Abigail Daane, South Seattle College

Additional Author | Elissa D. Levy, NYC Department of Education

Additional Author | Leslie Chamberlain, The Harpeth Hall School

As the climate change crisis continues to intensify, our response as a national community has moved at a (pre-industrial) glacial speed. We need to transform the physics canon and revise NGSS to connect issues of climate change with physics course content. Researchers have long documented students' tendency to rely on colloquial energy ideas, such as "saving energy from getting used up," instead of the conservation principle. And why should students not focus on energy in the real world? Our educational system needs to adjust the focus of our content to support student engagement with the pressing issues of today's society. This presentation is both a call to action and a demonstration of how a small change in a previously-taught lesson can lead to big connections and more relevant energy conversations in the classroom. In particular, we share an approach to connect energy in physics to climate-related energy topics.

POS2A05 (9:00 to 9:45 PM TUESDAY) Comparison of Discussions in Different Online Physics Classrooms for Educators*

Poster – Presenting Author: Bahar Modir, Texas A&M University-Commerce

Additional Author | Sai Kumar, Texas A&M University-Commerce

Additional Author | Michael Nadeau, Texas A&M University-Commerce

Additional Author | Robynne M. Lock, Texas A&M University-Commerce

Additional Author | William G. Newton, Texas A&M University-Commerce

Participation in online forums can support community learning in online classrooms. We have investigated the written discussion posts in online problem solving discussion boards of 3 physics courses in our recent work. These core courses are offered as part of the new online Master in Physics with Teaching Emphasis program at Texas A&M University-Commerce. Students in this program are mostly in-service high school physics teachers. In this poster, we compare the previously identified emerging discussion themes and explore the possible differences in kinds of discussions from course to course, and investigate the factors underlying the differences.

*This work is funded and supported by Texas A&M University-Commerce.

POS2A06 (7:45 to 8:30 PM TUESDAY) A Survey for Assessing Instructional Change Teams in Undergraduate STEM

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

Additional Author | Amreen Thompson, Texas State University

Additional Author | Alice Olmstead, Texas State University

Additional Author | Andrea Beach, Western Michigan University

Additional Author | Charles Henderson, Western Michigan University

Recently, many efforts to improve undergraduate STEM instruction encourage team formation. While team-based approaches are promising for enacting high quality and sustainable outcomes, they are also "risky." Our research group is currently developing a survey instrument for teams. This research builds on our prior work to develop an instructional change teams model. The model includes five team processes – strategic leadership, egalitarian power dynamics, team member commitment, effective communication, clear decision-making processes, and three emergent states – shared vision, psychological safety, team cohesion. Through the survey development, we aim to explore the interrelationships between all the major pieces in our model and provide formative feedback about team member collaboration. In this poster, I will describe the key parts of our emerging survey instrument and share preliminary findings from the psychometric evaluation of the pilot data. Finally, I will describe opportunities for teams to engage with our work.

POS2A07 (9:00 to 9:45 PM) | Poster | Student Attitude Changes and Curricular Benefits from Two Instructional Interventions

Poster – Presenting Author: Grant Kaufman, Illinois State University

Additional Author | Raymond Zich, Illinois State University

Additional Author | Jefferey Rosauer, Illinois State University

We report on a study comparing the impact on student attitudes about science and scientific reasoning skills of two instructional interventions applied in a single semester general education physics course. The first intervention had students watch videos on physics topics and complete worksheets testing their comprehension of the concepts and the scientific reasoning shown. The second intervention had students manipulate PhET simulations and complete worksheets based on the simulations. The results of these instructional interventions are presented for two control, three video treatment, and four PhET simulation semesters. The CLASS and Lawson's CTSR were used for pre- and posttests to assess changes in students' attitudes about science and students' scientific reasoning skills. Pre-post shifts in student attitudes were 3% toward more expert-like attitudes with the video interventions and 6.3% with the PhET simulations, and improvements of scientific reasoning skills of 4.2% with the videos and 7% with the PhET simulations.

POS2A08 (9:45 to 10:30 PM TUESDAY) From Volunteer to Program Leader: A Career in Informal Physics

Poster – Presenting Author: Bryan Stanley, Michigan State University

Additional Author | Kathleen Hinko, Michigan State University

Volunteering in informal physics programs can give physics students opportunities to collaborate and connect with their peers and physics faculty, apply their formal learning in real world situations, and support their physics identity. These experiences can impact the student volunteers' career pathways. Some volunteers go on to participate or even lead informal physics programs after leaving their post-secondary education. We hypothesize that this is in part influenced by some impactful informal physics experiences that led them to informal educational careers. In this poster, we present a case study on a current program leader and their former informal physics experiences as a university student. A case study approach serves as an initial step in identifying influential experiences which can aid in understanding the experiences of volunteers more broadly.

POS2A10 (9:45 to 10:30 PM TUESDAY) Supporting Instructors through Research-based Assessment

Poster – Presenting Author: James Laverty, Kansas State University

Additional Author | Amogh Sirnoorkar, Kansas State University

Additional Author | Alexander Adamson, Kansas State University

Additional Author | Josh Weaver, Kansas State University

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

Research based assessments have a productive and storied history in PER. While useful for conducting research on student learning, their utility is limited for instructors interested in improving their courses. We have developed a new assessment design process that leverages three-dimensional learning, evidence-centered design, and self-regulated learning to deliver actionable feedback to instructors about supporting their students' learning. We are using this approach to design the Thermal and Statistical Physics Assessment (TaSPA), which also allows instructors to choose learning goals that align with their teaching. Perhaps more importantly, this system will be completely automated when it is completed, making the assessment scalable with minimal burden on instructors and researchers. This work represents an advancement in how we assess physics learning at a large scale and how the PER community can better support physics instructors and students.

POS2A11 (9:00 to 9:45 PM TUESDAY) Developing a Physics Career Intervention Among Middle School Students

Poster – Presenting Author: Elizabeth Parisi, The College of New Jersey

Presenting Author | Jillian Ryan, The College of New Jersey

Additional Author | AJ Richards, The College of New Jersey

Our prior research has shown that students do not know the variety of careers within the physics discipline; many believe that engineering or teaching is the only outlet for professional physicists. This discourages many students from pursuing the field further. To investigate this issue further, we are designing an intervention aimed at educating middle school students about the variety of physics careers. The intervention also attempts to give students a more nuanced understanding of what physics is, beyond a typical classroom definition. In this poster, we outline the intervention study and provide examples of the modules to help guide teachers in implementing this program into their classrooms.

POS2A12 (9:45 to 10:30 PM TUESDAY) Rejecting the Gendered Boxes of Science

Poster – Presenting Author: Vashti Sawtelle, Michigan State University

Additional Author | Abigail R Daane, South Seattle College

In introductory physics, we often encourage students to see themselves as part of the physics community. To do so, we might highlight inclusive aspects of our classroom culture and the broader physics community. In this poster, we offer a lesson plan that we designed to critique certain ways of knowing in physics. In this lesson plan, we critique gendered science practices, norms, and assumptions as existing in defined boxes. The lesson is structured to support students in noticing, naming, and rejecting these boxes as they have experienced them in life and in their STEM classes. We then offer an alternative view in which STEM classes and culture do not conform to gendered practices and expectations, but instead open avenues for broader inclusion. We aim with this lesson and reflection on science to support students in developing agency to see their ways of being as an integral part of our community.

POS2A13 (9:00 to 9:45 PM TUESDAY) The Effect of Value-Focused Discussions on Scientists' Ethical Decision Making

Poster – Presenting Author: Tyler Garcia, Kansas State University

Additional Author | Bill Bridges, Kansas State University

Additional Author | James T Laverty, Kansas State University

Additional Author | Caitlin Solis, Kansas State University

Additional Author | Wyatt Jones, Kansas State University

Current ethics training shows little improvement in ethical decision making. Recent studies have shown that values play a much bigger role in science than what is normally accepted. We believe that by having discussions about the values found in decisions in science, we can improve scientists' ethical decision making. We are measuring better ethical decision making by seeing how scientists' awareness of ethical values and level of moral reasoning changed. We formed a fellowship of fifteen science faculty where they discussed the values embedded in various scientific norms to bring awareness to the values inherent in research practices. In order to see how the fellowship impacted the scientists' ethical reasoning, we conducted pre/post interviews where we asked "what would you do" in different ethical vignettes. We determined that scientists' identified more values and we are still looking at their ethical reasoning.

POS2A14 (9:45 to 10:30 PM TUESDAY) Student Perspectives on Social Justice and Equity in STEM

Poster – Presenting Author: Adrianna Chagdes, South Seattle College

Additional Author | Abigail R Daane, South Seattle College

Creating opportunities for STEM students to explore how social justice applies to their field and community is a vital component to their educational path. For this reason, South Seattle College offers a course exploring subjectivity and social justice issues in STEM. This course covers myriad topics, from climate change, to racial and gender discrimination, to feminist science. While we believe students benefited from all of these conversations, we analyzed students' final reflection essays to investigate what resonated most with students and why. Our analysis included identifying key phrases where students expressed a change in perspective or shared anecdotes related to the topics discussed. The results show a majority felt a personal connection to conversations about discrimination. Our analysis implies students used this opportunity to cultivate a critical relationship with racial and gender discrimination; confronting individual experiences with (in)actions and biases, and developing skills to create equity around them.

POS2A15 (9:00 to 9:45 PM TUESDAY) Nuanced Explorations of Personal Support Networks: A Cross-case Analysis

Poster – Presenting Author: Brian Zamarripa Roman, University of Utah

Additional Author | Miguel Rodriguez, University of Utah

Additional Author | Ramón S Barthelemy, University of Utah

As the physics education research community continues to address issues of equity concerning People of Color, it is essential to conduct investigations with consideration of the diversity of individuals to direct resources to effective support systems. This qualitative cross-case study examines the helpful and mentor relationships identified by two men of color enrolled in a physics graduate program to identify relevant characteristics influencing their support networks. Results show the value of postdocs, research advisors, family, roommates and academic peers in supporting the participants through concerns with research, motivation, and living expenses. Additionally, results highlight the critical role of advocacy for international students and the role of cultural background in facilitating different relationships. Ultimately, this study highlights the need for nuanced explorations to identify relevant supports for People of Color in physics to invest in relevant systems such as research group rotations, student-led organizations, and advocacy for international students and postdocs.

POS2A16 (9:45 to 10:30 PM TUESDAY) The Unfolding Roles of Mentors and Tutors in Learning-by-Teaching model

Poster – Presenting Author: Kathleen Falconer, Institute of Physics Didactics, University of Cologne, Germany

Additional Author | Stefan Hoffman, Institute of Physics Didactics, University of Cologne, Germany

Additional Author | André Bresges, Institute of Physics Didactics, University of Cologne, Germany

To boost student autonomy, traditional lectures have been replaced by a more active format integrating different student programs at the University of Cologne: Learning by Teaching (LbyT). The LbyT concept was researched and developed by using Action Research with the *teacher as reflective practitioner* model (1). The university faculty were simultaneously in the role of researchers as well as teachers exploring their own practices. Initial focus was on

their role as teachers and the scope and sequence of student activities. In further development of the courses, the agency of the roles of mentors and tutors unfolded. We analyzed and present the evolution these developments by considering the individual roles. (2) (3) Beyond, we present experiences for tutoring concepts in the typical first semester courses in experimental physics for more than 10 years, where physics students can gain initial experience teaching small learning groups starting their studies.

1. Kemmis, S. and Mc Taggart, R. (1988). The Action Research Reader (3rd ed.) Geelong, Victoria, Australia: Deakin University Press
2. Laudonia, I., Mamlok-Naaman, R., Abels, S., & Eilks, I. (2018). Action research in science education – an analytical review of the literature. Educational Action Research, 26(3), 480-495.
3. Gibbs, P., et. al. (2017). Literature review on the use of action research in higher education. Educational Action Research, 25(1), 3-22.

POS2A17 (9:00 to 9:45 PM TUESDAY) Operationalizing Academic Integration for Post-Transfer Students: Discussing Quantitative Factors

Poster – Presenting Author: Alyssa Waterson, Michigan State University

Additional Author | Rachel Henderson, Michigan State University

Research discussing the historic Tinto's Model of Retention has pushed "integration" as a key component to students' will to stay in or leave higher education. Though previous research has attempted to define factors that comprise "integration" for many student populations, it has been difficult to assess or come to an agreement upon what these factors may be for transfer students. Generally, transfer students encounter "integration" through the financial, academic, and social implications of becoming a student at their new four-year institution. This dialogue intends to identify aspects of academic integration that have been analyzed in existing educational retention models to then ask ourselves if they are appropriate for a transfer student population. Through this lens, we will discuss possible variables used to describe academic integration for post-transfer students, in which we consider the factors that may be found in registrar data and used in quantitative modeling to predict student retention.

POS2A18 (9:45 to 10:30 PM TUESDAY) Growing as a Change Agent: Slowing Down and Facilitating Teams

Poster – Presenting Author: Robert Dalka, University of Maryland, College Park

Additional Author | Diana Sachmpazidi, University of Maryland, College Park

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

Additional Author | Joel C Corbo, University of Colorado, Boulder

Additional Author | David A Craig, Oregon State University

The Departmental Action Leadership Institute (DALI) is an initiative that works with physics programs to implement institutional change within their departments. Each participating program sends two faculty members who attend ongoing DALI meetings for one year to learn and reflect on effective change practices. During that year, these change leaders facilitate local teams based on the Department Action Team (DAT) model. We present outcomes associated with individuals' professional growth, based on survey data, comparing current states of change leaders' abilities and their retrospective accounts prior to the DALI. These outcomes span areas such as change leaders' self-efficacy in facilitating DATs, partnering with students, and joint data sense-making. These data also highlight aspects of DALI participants attribute their growth to, as well as what could be improved. We hope this talk serves as inspiration and lessons learned for others partnering with faculty to develop capacity for change in physics programs.

POS2A19 (9:00 to 9:45 PM TUESDAY) Students' Roles in Faculty Student Partnerships

Poster – Presenting Author: Robert Dalka, University of Maryland, College Park

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

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

The practice of partnering with students on departmental projects and initiatives has grown within STEM and Physics programs. These collaborations between faculty and students span multiple contexts, from curriculum and classroom partnerships to institutional change efforts. While these partnerships produce more student-centered results and are able to engage a wider set of departmental stakeholders, they place students in complex roles in which they must navigate complicated systems. This presentation will attempt to summarize the literature student partnership initiatives and situate two ongoing research projects within this literature. The first concerns students who are members of Departmental Action Leadership Institute (DALI) affiliated Departmental Action Teams (DAT), working on institutional change within their programs. The second study is focused on undergraduates who take up the role of Network Fellows within the Access Network, an inter-institutional coalition that works towards a vision of a diverse, equitable, inclusive, and accessible STEM community.

POS2A20 (9:45 to 10:30 PM TUESDAY) Network Analysis of Likert-style Surveys

Poster – Presenting Author: Robert Dalka, University of Maryland, College Park

Additional Author | Diana Sachmpazidi, University of Maryland, College Park

Additional Author | Charles Henderson, Western Michigan University

Additional Author | Justyna P Zwolak, National Institute of Standards and Technology

Likert-style surveys are a widely used research instrument to assess respondents' preferences, beliefs, or experiences. This poster showcases a new methodology in which network analysis can be used to evaluate the interconnectedness of items in Likert-style surveys. The unique features of this approach are explored through an application of the methodology to the Aspects of Student Experience Scale (ASES) data set and a comparison of the results to principal component analysis. I show how a meaningful network based on student survey item response similarity is successfully created. I also demonstrate how modular analysis can be used in order to identify larger themes built from the connections between particular survey items. Our proposed methodology is widely applicable and provides a new way to investigate phenomena assessed by Likert-style surveys.

POS2A21 (9:00 to 9:45 PM TUESDAY) Investigating Student Interpretations of Differences Between Classical and Quantum Computers

Poster – 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

Significant attention in the PER community has been paid to student cognition and reasoning processes in undergraduate quantum mechanics. Until recently, however, these same topics have remained largely unexplored in the context of emerging interdisciplinary quantum information science (QIS) courses. We conducted

exploratory think-aloud interviews with 24 students in an upper-division quantum computing course at a large R1 university crosslisted in physics and computer science, as well as 5 graduate students in a similar graduate-level QIS course offered in physics. We classify and analyze students' responses to a pair of questions regarding the fundamental differences between classical and quantum computers, interpreting students' responses as a possible window into the underlying ontologies of quantum mechanics students develop through such coursework.

POS2A22 (9:45 to 10:30 PM TUESDAY) Machine Learning Techniques for Classifying Physics Performance

Poster – Presenting Author: John Pace, West Virginia University - Morgantown, WV

Additional Author | John Stewart, West Virginia University - Morgantown, WV

Additional Author | John Hansen, West Virginia University - Morgantown, WV

The application of various machine learning algorithms and techniques to the prediction of student performance in an introductory mechanics class is discussed (N = 2061 students). The dataset used for prediction includes institutional variables (GPA, credit hours) and in-class variables gathered from the first two weeks of class (homework and clicker scores). These variables are used to predict which students are at risk of failing the course (receiving a D or F). The effectiveness and implementations of random forest, logistic regression, and voting ensemble classification models are discussed. Various model optimization methods are explored including decision threshold tuning, model regularization, synthetic upsampling, and variable selection techniques. The best performing models achieved a balanced accuracy of around 80%.

POS2A23 (9:00 to 9:45 PM TUESDAY) Identifying Epistemic Frames in Faculty Discourse Centered around Ethics

Poster – Presenting Author: Bill Bridges, Kansas State University

Additional Author | Tyler Garcia, Kansas State University

Additional Author | Caleb Linville, Kansas State University

Additional Author | Wyatt Jones, Kansas State University

Additional Author | Caitlin Solis, Kansas State University

Scientists are encouraged to engage in some form of ethical training. A common criticism of these training modules is that they are not effective. We formed a fellowship of fifteen scientists to investigate different modes of engagement with value-laden topics to see how scientists would engage in more ethically-driven discussions. These scientists met for a series of group sessions over the course of an academic year. We examined these discussions through the lens of epistemic frames, and characterize these frames through a number of characteristics including behaviors, verbal cues, and epistemic forms. We use these characteristics to identify the frames present in the fellowship, and what factors influenced changes in frames. Categorizing discussions with epistemic frames offers an opportunity for identifying what is driving more ethically-minded discussions, and this knowledge could then be used to better design ethical training modules.

POS2A24A (9:45 to 10:30 PM TUESDAY) The Advantages and Disadvantages of Virtual Qualitative Interviewing*

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

Additional Author | Dedra Demaree

Additional Author | Michele McColgan, Siena College

Additional Author | Brad Moser

Additional Author | Tim Osborne, University of North Carolina @ Chapel Hill

When the Fluids Conceptual Evaluation (FCE) Team submitted our research grant proposal to the NSF IUSE program in February of 2020, we had no way of knowing that when we received the grant in October 2020, we had to adapt our research methodology for COVID-19. Originally, we had planned on traveling to 17 institutions to collect interview data for the qualitative portion of our development. Unfortunately, with COVID this was no longer possible. We elected to switch to Zoom virtual interviews. Over the last two years we have collected over 40 virtual interviews. Ironically, due to COVID, many of the individuals we interviewed were familiar with Zoom and this removed the final barrier for conducting virtual Zoom interviews. In this poster, I will highlight some of the major advantages and disadvantages in conducting virtual interviews with Zoom.

*Supported by the NSF project #2021059.

POS2A24B (9:00 to 9:45 PM TUESDAY) Development of Questions for the Fluids Conceptual Evaluation (FCE)

Poster – Presenting Author: Dawn Meredith, University of New Hampshire

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Additional Author | James Vesenka, University of New England

Additional Author | DJ Wagner, Grove City College

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

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. Rasch analysis will be used to create different equivalent versions of the FCE, allowing instructors to give just the statics questions, just the dynamics questions, or a combination of both. In this poster we will describe the development of student-based distractors for the FCE. IPLA instructors interested in serving as a pilot test site should contact Project Lead Dawn Meredith.

POS2A24C (9:00 to 9:45 PM TUESDAY) Refining Assessment Questions Based on Clinical Interviews

Poster – 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 fluid statics and dynamics. Initially we developed 101 tier-1 questions

covering 8 statics constructs and 9 dynamics constructs, with the intent of including 3 questions per construct in the final assessment. In the spring of 2021, we conducted 15 clinical interviews asking student volunteers selections from those questions. Analysis of interviews, and feedback from the interviewers, led to the revision, removal, and addition of several questions, which were used in the second round of interviews during the 2021-2022 academic year. In this poster we describe selected takeaways from this process, including some "dos and don'ts" for constructing robust questions. IPLS instructors interested in serving as a pilot test site for the assessment should contact Project Lead Dawn Meredith.

POS2A25 (9:00 to 9:45 PM TUESDAY) Understanding Physics Identity in Computationally Integrated Physics Classrooms.

Poster – Presenting Author: Jake Rodgers, Michigan State University

Additional Author | Paul Hamerski, Michigan State University

Additional Author | Daryl McPadden, Michigan State University

Additional Author | Marcos "Danny" Caballero , Michigan State University

Additional Author | Paul Irving, Michigan State University

We present an investigation into the impact that computation in the physics classroom has on a student's sense of identity. We ask: how does computation change what a "good student" means in a physics classroom? To test the hypothesis that computation adds a new layer to the meaning of a "good physics student," a series of interviews were conducted with AP Physics high school students. Using a norm and values card sort interview, students were asked: 1) about their perspectives on the practices and important values of their classroom and 2) to identify what it means to be a good physics student and what an ideal physics classroom looks like. The interviews demonstrated a clear impact on students' perceptions of what it means to be a good physics student and suggests that computation can be a roadblock in the students' minds, rather than a tool to understand concepts more deeply.

POS2A26 (9:45 to 10:30 PM TUESDAY) Queering Methodologies in Physics Education Research

Poster – Presenting Author: Madison Swirtz, University of Utah

Additional Author | Ramón Barthelemy, University of Utah

When we talk about "queer theory" in STEM education research, we often use it as a synonym for studying LGBT+ students or queer issues. However, queer theory and queer methods can be applied to discipline-based education research far more broadly. In this presentation I introduce a unique perspective on "queering" quantitative and qualitative research methods and highlight some of the ways these methods are already compatible with the goals of physics education research. This will include discussions of deconstructing binaries, empowering participants in the research process, and reimagining study design to attain novel insights about the experiences of physicists.

POS2A27 (9:00 to 9:45 PM TUESDAY) Addressing Subjectivity in Physics for Equity in Physics Education

Poster – Presenting Author: Andrea Wooley, Western Washington University

Additional Author | Thanh Lê, Western Washington University

Creating a more equitable scientific community is an important goal in physics. To this end, one approach is addressing students' views about the socially and culturally embedded nature of science (NOS) and increasing their awareness about the influence of subjectivity in physics. Identifying ways personal experience and values affect the culture of physics, may promote student self-efficacy and empower them to work towards greater social justice in physics. Prior studies reveal that without explicit instruction about the NOS, students tend to describe physics without reference to human influence. Adding to this, we explored undergraduate students' ideas about the presence of subjectivity in physics in an introductory calculus-based physics sequence and with prospective elementary teachers in a physics course. We collected written responses on whether students viewed physics as objective or subjective. In this talk, we discuss how student responses describe subjectivity in physics and argue for explicit NOS instruction.

POS2A28 (9:45 to 10:30 PM) Students' Experience of Small and Large Spatial Scales

Poster – Presenting Author: Elias Euler, Lund University

Additional Author | Jenny Sullivan Hellgren, Umeå University

Additional Author | Urban Eriksson, Lund University

This paper presents initial data and findings from a pilot study that aims to elicit how pre-service science teachers make sense of and relate to objects that are much bigger and/or much smaller than human scale. Small groups of pre-service physics and biology teachers were video-recorded while collaborating on a ranking task involving objects from the scale of a proton to the scale of the Universe. We analyse these interview data following a phenomenographic approach in order to identify some of qualitatively different ways that students come to experience and reason about spatial scales.

POS2A30 (9:45 to 10:30 PM TUESDAY) | Poster | Using the PhysPort Data Explorer to analyze research-based assessment results

Poster – Presenting Author: Sarah McKagan, American Association of Physics Teachers

Additional Author | Adrian M. Madsen, American Association of Physics Teachers

Additional Author | Lauren C. Bauman, University of Washington Bothell

The PhysPort Data Explorer (www.PhysPort.org/DataExplorer) is an online tool for physics instructors to analyze their research-based assessment data (including FCI, FMCE, BEMA, CSEM, CLASS, MPEX, and many more). Instructors upload their students' responses using our secure interface. The Data Explorer matches their pre/post data, scores it, compares it to national data, and graphs it in an interactive and intuitive manner. Instructors can look at results over time, breakdown by question or cluster, and comparisons between courses. Instructors can also upload data related to student demographics, academic record, or background, and look at their assessment results based on this information. We present the Data Explorer and discuss equity issues around analysis and interpretation of research-based assessment results, in order to support faculty in using data to reveal and address inequities, to more effectively support minoritized groups of students, and to minimize and eliminate harm.

POS2A31 (9:00 to 9:45 PM TUESDAY) Changing Notation That Represents Force Changes How Students Say It

Poster – Presenting Author: brant hinrichs, drury university

Additional Author | dayna swanson, drury university

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, 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 as "gravitational force", audio data from student-led whole-class discussions shows that more than 40% percent of the time 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 to 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. Energy.

POS2A32 (9:45 to 10:30 PM TUESDAY) Relating Computational Thinking Practices and Problem Design Features

Poster – Presenting Author: Tyler Stump, Michigan State University

Additional Author | Theodore Bott, Michigan State University

With the growing ubiquity of computation in STEM fields, understanding how to teach computational thinking (CT) practices has become an active research area in the last two decades, with particular emphasis on developing CT frameworks. In this paper, we apply one of these CT frameworks and correlate the results with a task analysis to examine how CT practices relate to specific design features of an in-class problem. We have analyzed video data from two separate groups working on one computational class period, which utilizes a minimally working program to model magnetic field vectors. While still in the initial stages of the study, our preliminary results indicate that what is left out of the minimally working program will impact the CT practices students use, particularly around building computational models. Ultimately, we hope this work will help instructors to design activities that can target & build specific CT practices

POS2A33 (9:00 to 9:45 PM TUESDAY) Shared Resources in Student Problem-Solving of Spherical Unit Vectors

Poster – 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.

POS2A34 (9:45 to 10:30 PM TUESDAY) Two Contentious Board Meetings; Social Positioning Correlates with Consensus Building

Poster – Presenting Author: brant hinrichs, drury university

Additional Author | david brookes, chico state

Additional Author | jake nass, drury university

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

POS2A35 (9:00 to 9:45 PM TUESDAY) Evaluating Patterns Across Educators in their Reflection of Computational Thinking

Poster – Presenting Author: Lillianna Mack, Michigan State University

Additional Author | Theo Bott, Michigan State University

Additional Author | Paul Irving , Michigan State University

Additional Author | Daryl McPadden , Michigan State University

Additional Author | Marcos Caballero , Michigan State University

As part of a computational thinking practices survey development process, five secondary educators with experience integrating computation into their physics classrooms were given a fourteen-practice computational thinking framework to reflect on and discuss. The computational thinking framework was presented to the teachers via a 54-question survey which they completed and then discussed in detail. This survey gathered data on which practices were the most important to these teachers, why each teacher felt the practices they chose were the most important, and how the practices were explicitly incorporated into their classroom. Our analysis of this survey shows that there are certain patterns across the educator's interpretation of these practices, as well as overlapping thoughts on the importance of computational thinking in the classroom. This initial data set will be used to iterate on the design of the survey and highlights variation in teachers' priorities related to computational thinking practices.

POS2A36 (9:45 to 10:30 PM TUESDAY) Nevertheless, She Persisted: The Impact of Persistence in Computation Education

Poster – Presenting Author: Megan Schwartz

As computation grows as a tool for scientists and engineers, there has been an increased interest in how to support STEM majors most effectively in the development of computational practices. It is important to support the development of computational practices for undergraduate students within majors like physics and mathematics as they have unique opportunities to operationalize computation in multiple contexts. We analyze the significance of the computational disposition "persistence" for an individual and how that impacts the group members around her. We present a representative case study of an individual who engages her group members through consistent persistence. We seek to propose a potential relationship between persistence and other computational thinking practices. Furthermore, we highlight opportunities for educators to encourage persistence in individuals that in turn serves their group. Through this analysis, we consider how creating collaborative environments in computationally integrated environments proves productive for students' tackling computational activities.

Pre-college/Informal and Outreach Posters

POS2B01 (9:00 to 9:45 PM TUESDAY) Place-based Education in High School Physical Science

Poster – Presenting Author: Molly German, Gridley High School

Additional Author | Rachel E Scherr, University of Washington Bothell

Additional Author | Jessica B Hernandez, University of Washington Bothell

In California and other western states, discussions about climate change and water access have become increasingly urgent. Connecting science learning inside the classroom to real issues that affect our students and their families is key to help students see science as a tool to work for change in their communities. Place-based education, which is rooted in historic and Indigenous educational practices, strongly supports these goals. In our Physical Science course for ninth and tenth graders, we added an outdoor experiential component to our "Science of Water" unit thereby placing our learning about water into our local context of rural Northern California. From the chemical properties of water, power generation via our local hydroelectric dam, decisions about water usage and the effects on ecosystems, and the implications of climate change, students can see the connections between all of these topics rather than learning each in isolation in separate courses.

POS2B02 (9:45 to 10:30 PM TUESDAY) Sustaining the Teacher-in-Residence Role

Poster – Presenting Author: Clay Stanfield, Texas A&M University-Commerce

Since 2015, Texas A&M University-Commerce (A&M-Commerce) has utilized the Teacher-in-Residence (TIR) program, funded through PhysTEC, in a variety of iterations. Each person serving in the TIR role fulfilled the unique responsibilities based on the status of the program at the time. The Physics Education Research team at A&M-Commerce was able to establish a permanent footprint in the College of Education and increase outreach at the high school and community college level by creatively using and staffing the TIR role and adapting it to emerging needs. The current focus is on establishing 2+2 plans with local community colleges as a pathway for graduation and certification for future secondary STEM teachers.

POS2B03 (9:00 to 9:45 PM TUESDAY) Roger That! A Celebration of Space Exploration (and Collaboration)

Poster – Presenting Author: Karen Gipson, Grand Valley State University

Additional Author | Samhita Rhodes, Grand Valley State University

Additional Author | Deana Weibel, Grand Valley State University

Additional Author | Glen Swanson, Roger B. Chaffee Scholarship Foundation

Additional Author | Rob Schuitema, Grand Rapids Public Museum

Additional Author |Jack Daleske, Grand Rapids Public Museum

Roger That! is a two-day public symposium on space exploration, organized by a multi-disciplinary team faculty at Grand Valley State University (GVSU) in collaboration with staff at Grand Rapids Public Museum (GRPM). GRPM is home to the Chaffee Planetarium, named in honor of local hero Roger B. Chaffee, who lost his life in the Apollo 1 fire. The symposium includes field trips and family-friendly activities, a design challenge for 4th - 6th graders, and presentations aimed at the general public. The inaugural event was in 2017; it was held in virtually in 2021, with limited in-person activities returning in 2022. The theme in 2022 was "Women and Space," with barrier-breaking astronaut Eileen Collins providing the live keynote, "Through the Glass Ceiling to the Stars." The GVSU chapter of the Society of Physics Students (SPS) supported this outreach by hosting spectroscopy activities at an open reception at GVSU bracketing the keynote.

Teacher Training/Enhancement Posters

POS2C01 (9:00 to 9:45 PM TUESDAY) BSU's Advanced Physics Academy: Combining Recruitment with Early Teaching Experiences

Poster – Presenting Author: Jeffrey Williams, Bridgewater State University

Additional Author | Allison Daubert, Bridgewater State University

Bridgewater State University (BSU), with funding from a PhysTEC Recruitment Grant has piloted an Advanced Physics Academy (APA) for high school students who have completed a year of any level of physics and are interested in majoring in physics or engineering. The APA serves as an early teaching experience for our Physics Education majors. Additionally, the APA highlights the work of BSU physics students and faculty to encourage students to apply to BSU and study physics as undergraduates. Initial efforts have been very successful; we hoped to enroll 20 students and actually enrolled over 40. Students attended four, three-hour workshops on the topics of optics and astronomy, relativity, semiconductor physics/LEDs, and photonics engineering. Feedback from the high school students indicate that they enjoyed the opportunity to learn undergraduate level physics and work in university lab spaces. Undergraduate pre-service teachers have benefited from helping to teach the high school students.

POS2C02 (9:45 to 10:30 PM TUESDAY) An Advanced Physics Academy: Combining Early Teaching Experiences with Recruitment

Poster – Presenting Author: Jeffrey Williams, Bridgewater State University

Additional Author | Allison Daubert, Bridgewater State University

Bridgewater State University (BSU), with funding from a PhysTEC Recruitment Grant has piloted an Advanced Physics Academy (APA) for high school students who have completed a year of any level of physics and are interested in majoring in physics or engineering. The APA serves as an early teaching experience for our Physics Education majors. Additionally, the APA highlights the work of BSU physics students and faculty in a hope to encourage students to apply to BSU and study physics. Initial efforts have been very successful. We hoped to enroll 20 students and enrolled over 40. Students attended four, three-hour workshops on the topics of Optics and Astronomy, Relativity, Semiconductors / LEDs , and Photonics Engineering. Our pre-service teachers have gained valuable experience teaching high school students as learning assistants in the classrooms.

POS2C03 (9:00 to 9:45 PM TUESDAY) Further Development of Out-of-Field High School Teacher Preparation

Poster – Presenting Author: Carlee Garrett

Additional Author | Jonathan Perry

Additional Author | Dawson Nodurft

Additional Author | Tatiana Erukhimova

Due to the low number of physics majors choosing to go into high school teaching positions, there has been an increasing number of physics classrooms led by teachers with little to no background knowledge. These limitations reduce the effectiveness of the class, and tend to go unaddressed by public school systems. The Mitchell Institute Physics Enhancement Program was created to address these issues through assisting out-of-field teachers in gaining necessary background knowledge. Over a two week period, participants work with physics faculty as well as two master high school physics teachers, training in both their subject knowledge and implementation. Participant pre- and post-program knowledge and confidence were measured using an assessment compiled of questions from mechanics, electricity and magnetism, optics, and modern physics. New results from the 2021 and 2022 cohorts will be presented. Analysis of our findings will also be discussed to encourage other institutions to create similar programs.

POS2C04 (9:45 to 10:30 PM TUESDAY) KITP Teachers' Conference: an Opportunity at the Frontiers of Science

Poster – Presenting Author: Jon Anderson, Centennial Schools and Univ. of Minnesota

Presenting Author | Jon Anderson, Centennial Schools and University of Minnesota

Presenting Author | Shane Wood, Mounds View Schools and QuarkNet

Additional Author | Maggie Sherriffs, Kavli Institute for Theoretical Physics, UC Santa Barbara

Each year, the Kavli Institute for Theoretical Physics (KITP, UC Santa Barbara) invites high school and community college teachers from across the United States to participate in a one-day conference of talks given by leading researchers. The teachers' conference is affiliated with one of KITP's collaborative physics research workshops. The conference emphasizes current research, rather than pedagogical practice. One third of each talk session is reserved for questions and discussion, and one third of the day is devoted entirely to informal interactions among teachers and researchers at all career stages. It is a chance to discuss diverse scientific topics, and for high school and university faculty to discuss physics careers and how to best encourage high school students to study physics, and how best to support them in their transition to physics bachelor's programs.

POS2C05 (9:00 to 9:45 PM TUESDAY) Professional Development for K-12 Teachers New to Physics Labs

Poster – Presenting Author: Bryn Bishop, The Art of Problem Solving

Many K-12 teachers are teaching physics for the first time and are unfamiliar with best practices for the management of labs, demos, and materials. When teachers feel uncomfortable with labs and equipment, they simply won't do the labs, to the detriment of their students. This is an area where experienced physics teachers can greatly support and empower those new to teaching physics. New teachers should be given time within a professional development setting to use lab materials, gain familiarity with best lab practices in the classroom, and learn how to organize equipment effectively and safely. I will discuss my experiences with leading "New Physics Teacher Workshops" as well as professional development for my company, including outreach to find teachers needing help, motivation for teachers to attend the PD, and the gains they have made through attending.

POS2C06 (9:45 to 10:30 PM TUESDAY) New Recruitment Strategies for Lewis University's Physics Teacher Preparation Program

Poster – Presenting Author: Joseph Kozminski, Lewis University

Additional Author | Brandi Fuller, Lewis University

Additional Author | James Hofmann, Lewis University

Additional Author | Dorene Huvaere, Lewis University

Through its PhysTEC recruiting grant, Lewis University has developed multiple strategies to grow its physics teacher preparation program. In Fall 2021, Lewis launched a five-year BS/MA program in physics and secondary education leading to licensure, which is expected to attract students deciding to pursue teaching later in their college careers and community college transfers. We have also modified Get the Facts Out resources to produce marketing materials, presentations for faculty and students, and an interactive website, which all incorporate local teacher salary data collected from seven Chicagoland counties and the City of Chicago. This presentation will discuss these marketing and recruiting efforts and provide an update on our successes and challenges in recruiting more students into our physics teacher preparation program. This work is supported by the National Science Foundation and the Physics Teacher Education Coalition (PhysTEC) under grant no. 1707990.

POS2C07 (9:00 to 9:45 PM TUESDAY) Using Critical Discourse Analysis—With Situational Logic to Reach Diverse Groups

Poster – Presenting Author: Yeaton Clifton

The case is made that to understand how to communicate with disadvantaged students it helps to study various forms of texts (including spoken discourse, written text and visual information) with formally coded data using Popper's situational logic as a means to critical discourse analysis. An example given will be discourse on climate change and efforts to subvert understanding of proper scientific reasoning. The goal of a science class is to teach correct scientific reasoning, and how the goal is affected by the discourse on climate is valuable information. In addition to the example, topics will include how to code data, how to define the rational goals of participants or subjects, and how apply what you learned to practical class rooms. Science rationality is central to this method, there will be discussion of how cognitive psychologists answer questions about who is rational and how rationality develops.

POS2C08 (9:45 to 10:30 AM TUESDAY) Reimagining Graduate Physics: Electricity and Magnetism for Educators*

Poster – Presenting Author: Robynne Lock, Texas A&M University-Commerce

Additional Author | Bahar Modir, Texas A&M University-Commerce

Additional Author | William G Newton, Texas A&M University-Commerce

The graduate physics curriculum has not changed significantly for several decades. However, given recent research advances and the broad range of careers available to those who possess physics degrees, redesigning some aspects of the curriculum may benefit students. At Texas A&M University-Commerce, we developed a fully

online Master of Science in Physics with Teaching Emphasis program to address the needs of a specific subset of students: Current high school physics teachers who wish to strengthen their content knowledge. We redesigned the core courses both to better address the needs of the teaching profession and to incorporate aspects of physics that are neglected in the traditional curriculum. In this work, I will describe the design of the Electricity and Magnetism for Educators course, which includes extensive reading and writing in addition to problem sets. Topics include Maxwell's equations, the historical development of electricity and magnetism, and current research.

*This work is supported in part by the National Science Foundation and the Physics Teacher Education Coalition (PhysTEC) under grant no. 1707990.

Technologies

POS2E01 (9:00 to 9:45 PM TUESDAY) LiDAR Motion Ranger on Your iPhone to Teach Kinematics Graphs

Poster – Presenting Author: Rebecca Vieyra, Vieyra Software

Additional Author | Chrystian Vieyra Cortés, Vieyra Software

Additional Author | Daniel O'Brien, Georgetown University

Additional Author | Colleen M Megowan-Romanowicz, American Modeling Teachers Association

Additional Author | Mina Johnson, Arizona State University

Learn how iPhone's new LiDAR technology can be used as a motion ranger to teach your students about position-time and velocity-time graphs. The newest iPhone versions make use of an array of infrared beams, allowing users to plot motion with high precision between about 30 cm and 4 m from an object. This free tool can be used with an introduction to kinematics, and helps build an embodied understanding of changes in speed and their corresponding graphical representations. Stop by to speak with one of the designers and to try a series of graph match challenges. This project is funded by NSF grant number 2114586 through an award to the American Modeling Teachers Association and Arizona State University.

POS2E02 (9:45 to 10:30 PM TUESDAY) PhysicsCHOPS – A Platform for Remote Collaborative Problem Solving

Poster – Presenting Author: Yu Wang, New York University

Additional Author | Yoav Bergner, New York University

PhysicsCHOPS is a web-based platform enabling students to solve problems in pairs. Although ordinary homework problems may be used, the power of PhysicsCHOPS comes from innovative item types: jigsaw and information-request (IR) tasks. Jigsaw tasks distribute needed information between two students such that neither one can solve the problems alone. IR tasks invite students to select information from a common set. To solve these problems, students need to coordinate a strategy collectively. PhysicsCHOPS can also evaluate solutions where each student provides a unique part of the answer (e.g., position and velocity). While group work has proven effective in the classroom, carrying out such activities when students are distributed remotely has always been challenging. PhysicsCHOPS not only enables remote collaboration but uses it as an opportunity to cultivate higher-order thinking skills. For example, withholding information compels students to reason through the solution strategy rather than plug and chug.

POS2E03 (9:00 to 9:45 PM TUESDAY) Creating an Interactive Simulation for Non-Inertial Reference Frames

Poster – Presenting Author: Colleen Countryman, Ithaca College

Presenting Author | Ted K Mburu, Ithaca College

The motion of non-inertial reference frames and the forces involved in understanding them (Coriolis and centrifugal forces) are challenging concepts for introductory and advanced mechanics students. Predicting trajectories of an object due to fictitious forces is another challenge for students. An effective way of presenting this new material has been to create a complex rotating apparatus with two cameras or to find footage of such an apparatus. We built an interactive simulation of the traditional apparatus that many students find helpful when trying to understand the motion of objects in non-inertial reference frames. Students can change both the velocity of an object and the angular velocity of the reference frame it is viewed in and then view a real-time, side-by-side comparison of the object in different reference frames. The simulation was built in JavaScript, so it will run on most browsers on a computer or mobile device.

POS2E04 (9:45 to 10:30 PM TUESDAY) Remote Sensing and Harmful Algal Blooms in the Finger Lakes

Poster – Presenting Author: ileana dumitriu, Hobart and William Smith Colleges

Additional Author | Julia Bellamy, Hobart and William Smith Colleges

Additional Author | Lea Mateo Medina, Hobart and William Smith Colleges

Additional Author | Peter Spacher, Rochester Institute of Technology

Additional Author | John Halfman, Hobart and William Smith Colleges

Harmful algae blooms (HABs) are a routine occurrence that compromise the many uses of the Finger Lakes. In-situ standard water quality testing to determine the presence of HABs in the lakes is often time consuming and expensive. The use of drones outfitted with camera and spectrometers could prove to be a more cost effective and efficient practice to detect HABs. Remote sensing of water faces many challenges, from cloud coverage and calibration techniques to water turbidity and surface glare from the sun. Given the many competing factors in remote imaging of water, it is essential to understand the connection between the images and the physical properties of the water. A study aiming to correlate trends in the optical images with water quality parameters was performed for eight eastern Finger Lakes. Undergraduate students enrolled in remote sensing course (co-taught physics/environmental studies, first-time-offered at HWS) were involved in this research.

POS2E05 (9:00 to 9:45 PM TUESDAY) Augmented Reality to Teach Magnetism Concepts

Poster – Presenting Author: Michele McColgan, Siena College

Additional Author | George Hassel, Siena College

Additional Author | Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Ed

Physics students often find visualizing 3-D abstract phenomena, such as magnetic fields of moving charges, magnets, current-carrying loops and long current-carry-

ing wires quite difficult. Instructors often utilize demonstrations and hands-on activities using magnets, coils of wire, iron filings, motors, and generators to help students master these concepts. Unfortunately, this is often not enough instruction, especially for students with weak spatial reasoning skills. Students need to be able to visualize these abstract concepts as part of understanding their exploration of the phenomena. We present a set of augmented reality models to help students visualize abstract 3-D magnetism concepts. We will present these visualizations in this talk and provide ideas for how to utilize the AR models in the classroom.

POS2E06 (9:45 to 10:30 PM TUESDAY) Cross-Platform Interactive Simulations for Introductory Physics

Poster – Presenting Author: Diego Valente, University of Connecticut - Storrs

Additional Author | Howard Winston, University of Connecticut - Waterbury

Additional Author | Steven Binz, Salisbury University

Additional Author | Gabriel Kovacs, University of Connecticut - Storrs

The use of new technologies for educational purposes has been the subject of great interest in the general education and discipline-based education research communities. In recent years, new technological developments have emerged in the domains of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). In this work we present our development of five AR and MR enhanced simulations to support instruction in a second semester introductory physics course covering electricity and magnetism. The simulations were designed to support student learning by leveraging the improved visualization, interactivity, and immersion opportunities these technologies afford. We present preliminary versions of our simulations developed for iOS and Android smartphones, Microsoft HoloLens devices, and traditional PCs. Mixed sets of these devices can share synchronized simulations anchored to common spatial locations, and participants are able to work together in person or remotely.

POS2E07 (09:00 to 09:45 PM TUESDAY) Replacing the LMS as an ADHD Professor and Web Developer

Poster – Presenting Author: Sam Hill, Adrian College

When the pandemic forced most of us online, many teachers made use of their college's Learning Management System. However, I have always found such systems to be slow and laggy, requiring way too many steps to update, and thus almost unusable to my ADHD brain. It was even more challenging during my wandering adjunct days when I might be teaching at multiple schools with their own systems and setups. Fortunately, I have dabbled in web development and was able to come up with an alternative. In this presentation I will describe some of the tools and practices I have created to replace the LMS with something more efficient for myself and my Students alike.

Upper Division and Graduate

POS2F01 (9:00 to 9:45 PM TUESDAY) Developing Clicker Questions on Larmor Precession of Spin in QM

Poster – Presenting Author: Paul Justice, University of Cincinnati

Additional Author | Emily Marshman, University of Plttsburgh

Additional Author | Chandralekha Singh, University of Plttsburgh

Engaging students with well-designed clicker questions is one of the commonly used research-based instructional strategy in physics courses partly because it has a relatively low barrier to implementation. Moreover, validated robust sequences of clicker questions are likely to provide better scaffolding support and guidance to help students build a good knowledge structure of physics than an individual clicker question on a particular topic. Here we discuss the development, validation and in-class implementation of a clicker question sequence (CQS) for helping advanced undergraduate students learn about Larmor precession of spin, which takes advantage of the learning goals and inquiry-based guided learning sequences in a previously validated Quantum Interactive Learning Tutorial (QuILT). The in-class evaluation of the CQS using peer instruction is discussed by comparing upper-level undergraduate students' performance after traditional lecture-based instruction and after engaging with the CQS.

POS2F02 (9:45 to 10:30 PM TUESDAY) Critical Energy Required for Intrinsically Localized Vibrations in NaI

Poster – Presenting Author: Benjamin Agyare, Stockton University

Intrinsically Localized Modes (ILMs) have been observed in NaI but only for wave-vectors at the corner of the 3-D Brillouin Zone. It has been suggested that for high-symmetry vectors, several van Hove singularities may converge at one frequency producing a large peak in the two-phonon density of state (DOS) and giving rise to ILMs. The experimentally determined nearest neighbor and next-nearest neighbor force coupling constants are applied to study the DOS spectrum for various center-of-mass momentum vectors, and their corresponding relative momentum vectors. Results show that the excitation spectra for a pair of harmonic phonons become energetically degenerate near the high-symmetry point L. The calculated critical energy corresponding to this high degeneracy is 20 meV. The formation of ILMs, or multi-phonon bound states is expected to arise because of anharmonic interactions that will lift these degeneracies to enhance the formation of ILMs.

POS2F03 (9:00 to 9:45 PM TUESDAY) Exploring Chaos by Creating Simulations of Nonlinear Systems

Poster – Presenting Author: Craig Wiegert, University of Georgia

As a capstone project in an upper-level undergraduate classical mechanics course, students were asked to choose a nonlinear system and create a computational model to investigate conditions under which the system might exhibit chaotic behavior. I'll discuss some of the systems that students could choose to investigate, describe the steps in their modeling process, and show a few examples of the presentations students created. Their computational models could easily be adapted into apparatus simulations for the purposes of taking and analyzing data.

Session IA: 21st Century Physics in the Classroom III

Location: CC: Grand Gallery A **Sponsor:** AAPT
Time: 9:10–9:50 a.m. **Date:** Wednesday, July 13 **Presider:** Shane Wood

IA01 (9:10 to 9:20 AM WEDNESDAY) Ocean Energy Imbalance and Climate Change in Beginning Physics

Contributed – Presenting Author: Thomas Gibbons, Eastern Iowa Community College District (Retired)

The temperature rise ΔT in a layer of ocean of mass m and specific heat c is related to ΔQ, the layer's energy imbalance (its energy input minus output), by ΔQ = mcΔT. That equation is familiar to beginning physics students, so it can be used to investigate a piece of the climate change problem in a beginning course. Specifically, it can relate published data on sea surface temperature to other data on energy imbalance. Using it on a thick layer of ocean requires that the temperature be independent of depth so that ΔT is well defined. That condition is valid near the surface. Thus we can calculate the energy imbalance of surface layers from NASA-GISS surface temperature data and investigate how that fits other energy imbalance measurements for deeper layers. This suggests that such calculations are meaningful.

IA02 (9:10 to 9:20 AM WEDNESDAY) Flipped Classroom Model with ALight Board

Contributed – Presenting Author: Papa touty Traore, Cheikh Anta Diop university

My pedagogy is flipped the classroom by using technology. Light board is an example of board where we can teach science and being face to face with your students . I recorded my topic and experiment from my house with some assignments to my students.The purpose is push students there own research and prepare the lesson. Once at class they will show and details the experiment or the worsheet. Using this method you can earn time and try to overcome the difficulty in the simplest way.

IA03 (9:20 to 9:30 AM WEDNESDAY) What Does 21st Century Physics Look Like?

Contributed – Presenting Author: Matthew Vonk, University of Wisconsin River Falls

Additional Author | Peter H Bohacek, Pivot Interactives SBC

Physics in the 21st century will be marked by these 5 characteristics.
-Active Engagement
-Embedded Science Practices
-Continuous, Personalized Feedback
-Unrestricted Exploration of Phenomena
-Multi-modal (Face-to-face an non-face-to-face)

What are the barriers that prevent so many of us physics teachers from achieving these ideals?

How can we overcome those barriers?

IA04 (9:30 to 9:40 AM WEDNESDAY) The Study of Physics in Institutions

Contributed – Presenting Author: Joselin Nyiawa Ngassa, University of Yaoundé 1

Today's scientific subjects constitute a major asset in the development and modernism of today's world. we are first of all interested in the usefulness of these subjects in everyday life, then we present the learning of physics as a flagship discipline in high schools and colleges and finally we present the difficulties that learners find in this discipline

IA05 (9:40 to 9:50 AM WEDNESDAY) Science 100

Contributed – Presenting Author: Donald Franklin, retired. consult for Openstax.college

The Science of Energy which is free to download from Openstax.college is a course designed to be used in small or poor high schools that do not have a yearly Physics class. This way the students get a full background in Science before attended science classes in post high school institutions.The ebook starts with Biology, then Chemistry, Earth and Space, and Physics. The best educator would have Physics in their background. If they can get a local post secondary school to approve the course and then give them college credit for the class. This can be better than an AP class.

Session IB: Best Practices in Educational Technology III

Location: CC: Grand Gallery B **Sponsor:** Committee on Educational Technologies
Time: 9:10–10:10 a.m. **Date:** Wednesday, July 13 **Presider:** TBA

IB01 (9:10 to 9:20 AM WEDNESDAY) Simple Innovative Hybrid Teaching Model to Make Hands on Experience

Contributed – Presenting Author: Ponnampalam Vijayakumaran, Jaffna National college Of Education, Kopay, Sri Lanka

Best practice innovative simple Hybrid teaching model with assessment and evaluation technique were constructed to science teacher training regarding physics electronic experiments to deliver the hands-on experiences by using a Smart phone via zoom conferencing to overcome COVID 19 pandemic. Every participant was asked to buy necessary electronic components by WhatsApp group. The model was demonstrated to keep the smart phone fixed in such a way the back camera was focused to an A4 sheet. Circuit was built up under the camera. Check list and observation schedule were used as assessment tools both ongoing practical session and uploaded video clips in WhatsApp group. 24 small electronics experiments were done by using bread boards and evaluated among 58 science prospective teachers of Jaffna National College of Education. 47 participants level of achievement was in very satisfied level and Others were reach near to competency level. So, this is an efficient model.

IB02 (9:20 to 9:30 PM WEDNESDAY) Blended Lab Teams: From Pandemic "hack" to Online Innovation*

Contributed – Presenting Author: Roland Woodward, University of Wisconsin Oshkosh - Fond du Lac

When our university imposed strict social distancing restraints in response to the pandemic, I developed a technique to offer introductory physics labs at our two-year access campus, whereby exactly one student per lab team actually came to the lab room and operated the equipment, and the remaining team members joined remotely. All team members worked together in real time using a shared Google Sheet, while simultaneously viewing the apparatus and communicating with one another through Zoom. I assigned POGIL-style roles to foster authentic collaboration and work balance within each team (and checked the Sheet's edit history after-

ward to be sure). In this talk, I describe the implementation details and technological challenges of this technique; outline its post-pandemic continuation as a student accommodation mechanism; and explore its potential as an alternative to "bootcamp" labs for "mostly-online" lab course delivery.
*[Additional information is available at https://www.thewoodwards.net/AAPT22SM.]

IB03 (9:30 to 9:40 AM WEDNESDAY) A Virtual and Interactive Learning Unit about Positron-Emission-Tomography

Contributed – Presenting Author: Sarah Zoechling, CERN & University of Vienna

Additional Author | Julia Woithe, CERN

Additional Author | Sascha Schmeling, CERN

Additional Author | Martin Hopf, University of Vienna

We have developed a new learning format to reach students around the world during the pandemic: virtual and interactive learning units. They consist of a unique combination of pre-recorded explanatory videos, interactive elements such as quizzes, screen experiments, and expert interviews. We consider interactive learning units to be very promising for incorporation into remote, blended, and face-to-face teaching and learning of physics. In this contribution, we present an interactive learning unit about Positron-Emission-Tomography created with H5P (cern.ch/petworkshop). PET is one application of particle physics in medical diagnostics, whereby particle detectors are used, for example, to locate a tumor. Empirical studies have shown that medical applications of physics are particularly interesting for students. We highlight the main components of the interactive learning unit about PET and provide ideas how to use the material in your physics lessons.

IB04 (9:40 to 9:50 AM WEDNESDAY) Replacing the LMS as an ADHD Professor and Web Developer

Contributed – Presenting Author: Sam Hill, Adrian College

When the pandemic forced most of us online, many teachers made use of their college's Learning Management System. However, I have always found such systems to be slow and laggy, requiring way too many steps to update, and thus almost unusable to my ADHD brain. It was even more challenging during my wandering adjunct days when I might be teaching at multiple schools with their own systems and setups. Fortunately, I have dabbled in web development and was able to come up with an alternative. In this presentation I will describe some of the tools and practices I have created to replace the LMS with something more efficient for myself and my students alike.

IB05 (9:50 to 10:00 AM WEDNESDAY) Course Lectures: My Transition from Zoom to DaVinci Resolve

Contributed – Presenting Author: Brian Woodahl, IUPUI

During the pandemic, I changed from how I presented the virtual lectures in algebra-based intro physics 1 and 2. I initially presented the lectures synchronously using Zoom. But after one semester, I realized a better method was available. Video record my lectures using a two-camera set-up (one on my face and the other on my notepad), then edit using DaVinci Resolve and post on YouTube for asynchronous viewing by the students.

IB06 (10:00 to 10:10 AM WEDNESDAY) Application of the Arduino Platform in Education

Contributed – Presenting Author: Lejla Jelovica, Faculty of Science, University of Split, Croatia

Presenting Author | Lejla Jelovica, Faculty of Science, University of Split, Croatia

Additional Author | Nataša Erceg, Faculty of Physics, University of Rijeka, Croatia

Information and communication technologies in education offer a variety of tools for learning as well as learning assistance. An example is the Arduino computer platform, which offers an experimental settings for measuring different physical quantities combined with available sensors (eg temperature or humidity sensor). Like similar platforms, the Arduino stimulates students' motivation and interest in conducting physical experiments in a more innovative way. The paper presents an experiment in which the heat capacity of water is determined by real-time temperature change using the Arduino Uno platform and its components, temperature sensors and designed software, with a high percentage of precision. Unlike the classical experiment, this approach allows students to participate in the development of devices that can be used in a variety of research projects and the acquisition of program skills, and can be applied at the primary school, high school, and university levels. Keywords – ICT; education; Arduino; experiment

Session IC: How Curt Hieggelke Contributed to Physics Education I

Location: CC: Grand Gallery Overlook G **Sponsor:** Committee on Physics in Two-Year Colleges
Time: 9:10–10:10 a.m. **Date:** Wednesday, July 13 **Presider:** Thomas O'Kuma

IC01 (9:10 to 9:40 AM WEDNESDAY) Curt Hieggelke in Joliet and Illinois

Invited – Presenting Author: William Hogan, Joliet Junior College

I was fortunate to meet Curt Hieggelke almost 30 years ago when I was a research physicist looking to get hired as an adjunct. I eventually became Curt's full-time colleague at Joliet Junior College. In addition to his well-known national work that others will focus on, Curt cared deeply about Joliet Junior College and the local AAPT Sections (Illinois Section, Chicago Section). Curt made a huge difference at the college where among other things he served at various times as a department chair, president of the faculty union, and an influential voice on any committee that involved technology at the college. Curt also was very involved in the Illinois Section where he served as an officer, meeting host, and seemingly permanent member of the executive council. My talk will focus on Curt's local accomplishments.

IC02 (9:40 to to 10:10 AM WEDNESDAY) Curt Hieggelke and Tasks Inspired by Physics Education Research (TIPERs)

Invited – Presenting Author: Steve Kanim, New Mexico State University

Curt Hieggelke was a friend, a colleague, and a mentor to me. He approached me not long after I graduated to propose that we work together with David Maloney and Tom O'Kuma to develop PER-based curricular materials that could be blended into otherwise fairly traditional physics classes to improve students' conceptual understanding. With NSF support, we developed three workbooks of TIPERs – Tasks Inspired by Physics Education Research – that included physics questions in a variety of formats to be used as homework, as in-class exercises, or as evaluation materials. Over a period of about 16 years, we wrote, refined, edited, and tested these questions, and gave workshops to encourage their use. I will describe Curt's leadership of these projects, and give examples of questions and question styles that Curt created.

Session ID: Innovations in Teaching Astronomy I

Location: CC: Grand Gallery C **Sponsor:** Committee on Space Science and Astronomy
Time: 9:10–10:10 a.m. **Date:** Wednesday, July 13 **Presider:** Janelle Bailey

ID01 (9:10 to 9:40 AM AM WEDNESDAY) Rubin Observatory's Approach to Improving Data Fluency

Invited – Presenting Author: Ardis Herrold, Vera C. Rubin Observatory

Imagine your students working together on an activity that engages them with authentic data, is aligned with topics you already teach, and builds their confidence in doing science, while becoming more data fluent. Rubin Observatory has developed free, online investigations that use intuitive data visualizations and interactive analysis tools. Investigations are designed to take into account classroom time and technology constraints, and address the reasoning levels and common learning challenges of students. While they can be used asynchronously, a face to face setting is optimal for active-learning and discussion. These investigations are appropriate for students in advanced middle school through "Astro 101" college courses. They are accessible to students of all backgrounds and abilities. All investigations incorporate the three-dimensional learning design of the NGSS and come with extensive teacher support materials, including formative and summative assessments.

ID02 (9:40 to 10:10 AM WEDNESDAY) A Spatial Curriculum for Teaching Seasons

Invited – Presenting Author: Archana Dobaria, Temple University

In this talk, I will present a methodical (step by step) spatial curriculum focused on teaching students about the complex astronomy concept of seasons. The curriculum teaches students about seasons using spatial activities to improve their spatial thinking, reasoning, and conceptual understanding of the topic. This spatial curriculum requires minimum material and is easy to implement for middle or high school students. The curriculum was implemented in 6th grade at a STEM school. The 7-lesson plan curriculum includes spatial components like 2D and 3D drawings, videos, and simulations combined with group discussions. Students use digital diaries (Google Slides) as means for journaling and learning about various concepts related to the seasons. The implementation showed that spatial activity improved students' spatial thinking and reasoning. Students also demonstrated an overall increase in conceptual understandings about seasons and showed more interest in learning new astronomy topics using a similar spatial curriculum.

Session IE: PER: Curriculum and Instruction III

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Research in Physics Education
Time: 9:10–10:10 a.m. **Date:** Wednesday, July 13 **Presider:** TBA

IE01 (9:10 to 9:20 AM WEDNESDAY) Improving Student Understanding of the Uperational Definition of Electric Field*

Contributed – Presenting Author: Safana ismael, North Dakota State University

Additional Author | Mila Kryjevskaia, North Dakota State University

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Mackenzie Stetzer, The University of Maine

Operational definitions play an important role in all sciences, from psychology to physics. Yet, students often struggle to understand their applications or practical significance. For instance, research suggests that introductory physics students struggle to apply the operational definition of an electric field based on the expression E=F/q. Some students have difficulties analyzing how the variables E, F, and q are affected when a specific change (e.g., increasing the charge on a test particle, q) is made. In this talk, we will present results from a study aimed to disentangle three aspects of student thinking that impact performance in this context: intuition, conceptual understanding, and mathematical reasoning. We will briefly describe two separate instructional approaches developed to leverage different aspects of student thinking and discuss the results of their implementations. Implications for research and instruction will also be considered.
*NSFGrant Nos. DUE-1431940, DUE-1431541, DUE-1431857, DUE-1432052, DUE-1432765, DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, DUE-1821561

IE02 (9:20 to 9:30 AM WEDNESDAY) I ACORN Physics Tutorials for Building on Seeds of Science

Contributed – Presenting Author: Sarah McKagan, American Association of Physics Teachers

Additional Author | Amy D. Robertson, Seattle Pacific University

Additional Author | Lisa M. Goodhew, Seattle Pacific University

Additional Author | Lauren C. Bauman, University of Washington Bothell

Additional Author | Adrian M. Madsen, American Association of Physics Teachers

ACORN Physics ("Attending to Conceptual Resources in Physics") Tutorials are a part of a broader effort to understand and cultivate the wonderful ideas that students use as they learn physics. These tutorials are designed to help instructors pay attention to and build from students' common, fruitful ideas (" conceptual resources") that represent seeds of science. We have done research to identify conceptual resources that students use as they learn about kinematics, linear momentum, forces, circuits, mechanical waves, and heat and temperature -- so that we can bring you tutorials that elicit and build from student resources and provide you with pragmatic support to implement these tutorials. You can access all of our materials, including the tutorials, videos of students using them, questions to help you prepare to use them, conceptual questions that you can build in to your curriculum, and overviews of our research, free from our website at https://www.physport.org/curricula/ACORN

IE03 (9:30 to 9:40 AM WEDNESDAY) Scaffolding Writing in Physics Labs

Contributed –Presenting Author: Anna Mederer, Worcester Polytechnic Institute

Additional Author | L Dana, Worcester Polytechnic Institute

Additional Author | Benjamin Pollard, Worcester Polytechnic Institute

Communicating physics is an essential learning outcome for undergraduate physics courses because it facilitates the synthesis of students' ideas, is a useful professional skill, and is the basis of sharing knowledge with a broader community. Physics lab courses are an ideal setting to learn these communication skills. Writing is an important subset of communicating physics, which has been explored in the "Framework of Goals for Writing in Physics Lab Classes" from Hoehn and Lewandowski. The overall goal of this project is to use this framework to understand how students acquire writing skills in physics, to structure labs to support learning

those skills, and to measure the effectiveness of scaffolding writing skills into the lab sequence. At our institution, we are restructuring the lab sequence to scaffold writing skills. We collected and analyzed student writing samples and open response feedback surveys and will present preliminary results.

IE04 (9:40 to 9:50 AM WEDNESDAY) Role of Preparatory Physics Foundation Course in Student Success

Contributed – Presenting Author: Binod Nainabasti, Lamar University

Additional Author | Cristian Bahrim, Lamar University

For 15 years, the Physics Department at Lamar has offered a Preparatory Physics Foundation (PPF) course for students with an insufficient physics background (optional), and for those with less than 620 Math SAT scores (mandatory). The goal of this course is to provide a robust conceptual understanding of physics and to help develop mathematical skills that are required for successful completion of calculus-based intro physics courses. We analyzed five years of data (2016-2021) and found that the PPF course has significant influence in reducing the fail/drop rate in the intro physics courses to about 20% less than for students without the PPF course. The PPF course focuses on quality instruction by offering a plethora of physics demos, encouraging peer conversations, and developing our students' mathematical skills to be applied to physics problems. Its content puts emphasis on basic mechanical concepts of kinematics and dynamics; through graphical analysis and vector manipulation.

IE05 (9:50 to 10:00 AM WEDNESDAY) Student Preferences About Instructional Explanation Strategies in Introductory Physics Classes

Contributed – Presenting Author: Joe Olsen, Rutgers University

Additional Author | Debbie Andres, Paramus High School

Additional Author | Charles Riggieri, Rutgers University

Instructional explanations (hereafter explanations) are ubiquitous in all classroom formats in introductory physics. While there is a large body of work exploring the range of strategies that are employed in explanations and their effect on learning, not much is known about the relationship between student preferences for certain explanation strategies and the strategies that are known to be effective. We claim this is important to understand, as student preferences will influence perceptions of instructor efficacy and learning regardless of student learning outcomes. To explore this relationship, we asked first-year engineering students in a large enrollment introductory physics course to compare pairs of explanations generated by highly regarded instructors (including undergraduate learning assistants, graduate teaching assistants, and faculty) and describe the criteria they used to determine which explanation was better. We conclude with commentary about the need to balance student preference with explanation qualities known to positively impact student learning outcomes.

IE06 (10:10 to 10:20 AM WEDNESDAY) Improving Introductory Physics Students' quantitative Reasoning through Targeted Practice

Contributed – Presenting Author: Alexis Olsho, United States Air Force Academy

Additional Author | Charlotte Zimmerman, University of Washington

Additional Author | Andrew Boudreaux, Western Washington University

Additional Author | Joseph Olsen, Rutgers University

Covariational reasoning--considering how changes in one quantity affect another, related quantity--is a foundation of quantitative modeling in physics, and a learning objective of introductory physics instruction at the college level. Our prior work suggests that covariational reasoning in physics contexts differs from that in purely mathematical contexts, and is effortful even for well-prepared students. We also find that students' covariational reasoning does not improve substantially as a result of introductory physics instruction. To address these issues, we have begun work to identify subskills that underlie productive covariational reasoning in physics contexts. We present our preliminary work on the identification of "essential skills" related to covariational reasoning, and the development of a set of targeted online tasks to improve those skills.

Session IF: PER: PER: Diverse Investigations II

Location: CC: Grand Gallery E **Sponsor:** Committee on Research in Physics Education
Time: 9:10–10:10 a.m. **Date:** Wednesday, July 13 **Presider:** TBA

IF01 (9:10 to 9:20 AM WEDNESDAY) Qualitative Social Network Analysis and Applications in Physics Education Research

Contributed – Presenting Author: Camila Amaral, University of Utah

Additional Author | Madison Swirtz, University of Utah

Additional Author | Justin A Gutzwa, University of Utah

Additional Author | Ramón Barthelemy, University of Utah

Social Network Analysis (SNA) has been used to study the interactions and connections between physics students in the classroom. Although there are different approaches to SNA, most research in PER collects complete networks of classrooms and utilizes quantitative methods, analyzing students' position in the network and focusing on numerical metrics. In this presentation other approaches to SNA will be discussed, including Egocentric SNA and other qualitative approaches. That talk will end with examples from recent PER literature focused on possible uses of SNA.

IF02 (9:20 to 9:30 AM WEDNESDAY) Trajectories of Transfer Students Toward a Bachelor's Granting University

Contributed – Presenting Author: Frank Dachille, San Jose State University

Additional Author | Gina Quan, San Jose State University

In this presentation, we will discuss the trajectories of undergraduate physics transfer students into a bachelor's granting university. Students in the study attend a large, public bachelor's granting university in which a significant fraction of undergraduate physics majors are transfer students. In one-on-one interviews, students discussed their academic and personal experiences before, during, and after their transition from community college(s) to a bachelor's granting university. During the interviews, we adapted the life grid methodology to track student's career and skill development over time. In this talk, we will discuss how their career and skill development evolves through their higher education path. We then consider how these paths complicate common narratives about the time students spend in a community college and bachelor's granting university.

IF03 (9:30 to 9:40 AM WEDNESDAY) Using a Mixed Methods Approach to Study Complex Motivational Constructs

Contributed – Presenting Author: Rachel Henderson, Michigan State University

Additional Author | Carissa Myers, Michigan State University

Additional Author | Vashti Sawtelle, Michigan State University

Traditionally, measurement of quantitative changes in students' motivational characteristics over an academic semester have been measured using pre- and post-test surveys. However, with the complexity of such constructs, a pre-post design may limit deeply understanding the impacts that curricular and co-curricular activities have on students. In this research, we have designed and implemented a mixed methods approach to investigate one such complex construct, students' self-efficacy -- or the confidence in one's own ability to perform a task. We employ the Experience Sampling Method (ESM) with in-the-moment survey measurements to quantify a shift in their self-efficacy followed by a qualitative daily reflection to further investigate the threats and/or supports that may have influenced that change. In this talk, I will present our research design and discuss our efforts toward validating our methodology. Generally, we are hopeful that this research design has possible versatility within STEM education research more broadly.

IF04 (9:40 to 9:50 AM WEDNESDAY) Changing Notation That Represents Force Changes How Students Say It

Contributed – Presenting Author: Brant Hinrichs, Drury University

Additional Author | Dayna Swanson, Drury University

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, 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 as "gravitational force", audio data from student-led whole-class discussions shows that more than 40% percent of the time 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 to 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. Energy.

IF05 (9:50 to 10:00 AM WEDNESDAY) Effectiveness of Introductory Physics Laboratory Courses in Supporting Learning Goals

Contributed – Presenting Author: Rachel White, Old Dominion University

Additional Author | Dr. Alexander Godunov, Old Dominion University, Department of Physics

Additional Author | Dr. Charles Sukenik , Old Dominion University, Department of Physics

This mixed methods research case study addresses the design of introductory physics lab courses at a university from the perspective of the physics teaching faculty and students. The data from this research is being used for the development of a theoretical framework to strengthen the global need for integrated STEM education. The AAPT Physics Education recommendations for the Undergraduate Physics Laboratory Curriculum (2014) identified six focus areas: constructing knowledge, modeling, designing experiments, developing technical and practical laboratory skills, analyzing, and visualizing data, and communicating physics. Participants responded to a four-point Likert scale on each of the AAPT six focus areas with open-ended questions to further articulate their experiences with physics lab courses. Students were administered a pre-and post-survey as well as five Likert scale questions on their STEM self-efficacy. The results, as well as the development of the integrated STEM theoretical framework, will be discussed.

IF06 (10:00 to 10:10 AM WEDNESDAY) Modeling Pathways to Access in Physics Learning and Research Environments

Contributed – Presenting Author: Jacquelyn Chini, University of Central Florida

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

We draw on data from interviews with physics instructors and research mentors, interviews with physics students, and surveys of the physics community to model how physics gatekeepers respond to the access and inclusion needs of disabled undergraduate and graduate students. While we continue to develop this model, we will discuss a priori and emergent model features. We compare the differential pathways to access through two common mechanisms: institutional accommodations and inclusive practices. Then, we discuss an emergent mechanism from our data: gatekeepers provide access to "students who need it". We argue that gatekeepers who provide access to "students who need it" likely have good intentions, such as demonstrating care and treating disability as a facet of diversity. However, we describe several challenges with this mechanism, such as the role of power in which students share their access needs and which students are evaluated by gatekeepers as "needing" alternative access.

Session IG: Sports Meets Physics I

Location: CC: Grand Gallery F **Sponsor:** Committee on Educational Technologies
Time: 9:10–10:10 a.m. **Date:** Wednesday, July 13 **Presider:** Andre Bresges

IG01 (9:10 to 9:40 AM WEDNESDAY) Kung Fu Physics

Invited – Presenting Author: Thommy Boehlig, Wing Tsjun International, Hackhausen 2c, 42697 Solingen, Germany

Additional Author | André Bresges, University of Cologne, Institute of Physics Education, 50931 Cologne, Germany

There is a lot of Physics to discover when you take your class on a journey to discover the Art of Kung Fu. Ancient Chinese scholars spent countless time observing the dynamic properties of human and animal bodies to build the complex systems of chinese martial arts. Modern concepts of physics, like conservation of momentum, vector decomposition, and the observation of location, speed and acceleration with high-speed cameras shed new light on the science behind Kung Fu. ogether with Kung Fu Grandmaster Thommy Luke Boehlig, we will dissect certain non-harmful moves of Wing Tsjun Kung Fu and analyze them with methods that can be easily applied in physics classes. We will provide you with worksheets to conduct this part of inquiry learning in class, and connect you with a network of Kung Fu Trainers close to your school or university that may provide additional insights in your classes.

IG02 (9:40 to 10:10 AM WEDNESDAY) Tactile Reaction Training in Physics Classes

Invited – Presenting Author: Sascha Therolf, University of Cologne

Additional Author | André Bresges, University of Cologne

How might we use breaks in physics classes to provide a meaningful experience, heighten cooperation and concentration, and provide more safety for kids on the way

to school?We developed a Tactile Reaction Training TRT that can be embedded in physics classes without compromises to lab safety. The training was about ten minutes for each of them and focused on getting a better body feeling to react more appropriately in danger situations. Aspects of Germany's core curriculum in Physics, e.g. conservation of Momentum, Force and Motion is connected to the training.

Session JA: How Curt Hieggelke Contributed to Physics Education II

Location: CC: Grand Gallery Overlook G **Sponsor:** Committee on Physics in Two-Year Colleges
Time: 10:20–11:20 a.m. **Date:** Wednesday, July 13 **Presider:** Thomas O'Kuma

JA01 (10:20 to 10:50 AM WEDNESDAY) My Excellent Adventure with Curt (and Tom)

Invited – Presenting Author: David Maloney, Purdue University Fort Wayne

My adventure with Curt Hieggelke (and Tom O'Kuma) focused on two primary activities: introducing TWC and high school faculty to interactive engagement, and developing materials to promote conceptual understanding. We started our journey when Curt and Tom took an AAPT workshop I presented at the 1990 winter meeting in Atlanta. At the following summer meeting in Minneapolis Curt asked me if I would be willing to be a co-presenter for similar workshops for a grant project he was submitting to NSF. I said yes little knowing that I was agreeing to a 25 year adventure. The series of workshops that Curt and Tom (and later Dwain Desbien) ran initially for TYC faculty, later to include high school instructors, was an extremely productive experience. That project subsequently morphed into developing curriculum materials to promote sense making for introductory physics. Curt was the critical element for all of these efforts

JA02 (10:50 to 11:20 AM WEDNESDAY) How Curt Shaped My Entire Career and PER

Invited – Presenting Author: Dwain Desbien, Estrella Mountain Community College

Curt Hieggelke was one of the largest contributors into making me the instructor I am today. His influence on me shaped my PER research goals, my career goals, and my desire to make an impact in TYC Physics teaching. This talk will share my personal experiences with Curt, his influences on me and how he made me a better instructor and colleague.

Session JB: Innovations in Teaching Astronomy II

Location: CC: Grand Gallery C **Sponsor:** Committee on Space Science and Astronomy
Time: 10:20–11:20 a.m. **Date:** Wednesday, July 13 **Presider:** TBA

JB01 (10:20 to 10:30 AM WEDNESDAY) Astronomy Education Study – Space for All: International Astronomy Education Efforts

Contributed – Presenting Author: Christine Hirst Bernhardt, Albert Einstein Educator Fellowship

Research in astronomy education is largely centered on the undergraduate level, or focuses on conceptual learning of Earth and Sun motion. A multinational astronomy education survey in formal education has never been completed at the K-12 and community level. This project will inform future studies and collaborations between educators and researchers, and provide examples of astronomy integrations in coursework and community. This project utilized interview and survey data to inform comparisons and case studies of international K-12 astronomy education efforts in community and formal education spaces. Space science is now embedded into science standards in the United States, however most educators do not have the content knowledge of how to incorporate this science into their existing coursework. I interviewed informal and formal educators who are using astronomy as a bridge to inspire STEM learning, particularly in marginalized communities. This study leverages Salimpour's (2021) work the "gateway" science of astronomy.

JB02 (10:30 to 10:40 AM WEDNESDAY) Teaching with Astronomy Smartphone Simulations

Contributed – Presenting Author: Kevin Lee, University of Nebraska

Additional Author | Christopher M. Siedell, University of Nebraska

This presentation will describe the desirable characteristics of HTML5 astronomy simulations targeted at smartphones and show several examples illustrating these characteristics. We will summarize current thinking regarding "best practices" for smartphone simulation usage in the classroom, covering what we have learned from our experiences and detailing a wish list of what we hope to learn in the future. Publicly available simulations will be described as well as possible avenues for building upon the classroom experience with student simulation work outside of the classroom.

JB03 (10:40 to 10:50 AM WEDNESDAY) Space Exploration Activities for Introductory Astronomy

Contributed – Presenting Author: Shannon Willoughby, Montana State University

Additional Author | Rebecca Vieyra

Additional Author | Ramon Lopez, University of Texas Arlington

Additional Author | Bahereh Samie, Temple University

Additional Author | Janelle Bailey, Temple University

We have developed and field tested two new lecture tutorial style activities for college level introductory astronomy students. Both encourage students to think critically about challenges associated with human space travel. In the activity Migration to Mars, students consider what supplies need to be taken on a trip to Mars, dangers posed to the human body while traveling in space, and the costs associated with this type of space travel. Students are challenged to creatively communicate their imagined travels to and from Mars by depicting Instagram posts. In the Solar Sails activity, students compare and contrast different rocket types: ion thrusters, chemical rockets, and solar sails. They also think about the relative fuel efficiency of each type of rocket, destination-specific communication delays, and requirements for extrasolar ships to be unmanned and autonomous. Activities and student reactions to them will be shared in this talk.

Session JC: Methods of Remediation in the Intro Physics Classroom

Location: CC: Grand Gallery B **Sponsor:** Committee on Physics in High Schools
Time: 10:20–11:20 a.m. **Date:** Wednesday, July 13 **Presider:** Debbie Andre

JC01 (10:20 to 10:50 AM WEDNESDAY) Resubmission Processes in University Lecture Classrooms

Invited – Presenting Author: Allison Daubert, Bridgewater State University

Bridgewater State University has successfully been using a resubmission process for formative assessment quizzes and summative assessment tests in certain lecture sections of our algebra based physics course. Each section contains 32 students and there are no teaching assistants or recitation sections. Students can earn points back on formative assessment quizzes through the use of a 'points recovery application'. Students can earn points back on summative assessments tests through a process that involves correcting the original test problem, teaching the material to the instructor or a Peer Learning Assistant, and then taking a new test under original testing conditions to replace the original grade. Through this process, students report increased satisfaction with the course, increased learning, and enhanced well-being.

JC02 (10:50 to 11:20 AM WEDNESDAY) Revise and Resubmit: Authentic Engagement in the High-school Physics Laboratory

Invited – Presenting Author: Danielle Bugge

National organizations such as AAPT and NGSS set goals of engaging students in experimentation and authentic scientific reasoning in the classroom. In ISLE approach classrooms, students participate in the practices of scientists on a daily basis. They design and carry out observational, testing, and application experiments and write up their findings both individually and collaboratively as laboratory reports. As educators, we are aware that developing these essential skills and practices takes time. Providing first-year high school physics students the opportunity to revise their laboratory reports to demonstrate improved understanding helps them cultivate the habits of mind of practicing scientists and enhances their well-being. This talk shares strategies for incorporating resubmissions of written lab reports into the classroom. Furthermore, it reports on findings from a three-year empirical study on the impact of revising lab reports on high school physics student scientific ability development in an ISLE approach classroom.

JC03 (11:20 to 11:50 AM Wednesday) Modeling a Remediation Policy Focused on Developing Epistemic Knowledge

Invited – Presenting Author: Jade Pinheiro, Paramus High School

As educators, we know that remediation is a fundamental part of the learning process, but how do we actively motivate students to engage in self-reflection and develop epistemic knowledge? During the last few years, I have focused on creating and implementing a remediation-based assessment model in my high school physics classes. This model sets out to eliminate fear of failure and encourage academic risk-taking through rewarding metacognition. Students were given standards-based feedback and the opportunity to participate in a universal reflection-and-retake policy to demonstrate their progress toward achieving targeting learning goals. Through this process, students were prompted to self-reflect and identify root conceptual difficulties, revise work and show evidence of understanding, and then take a reassessment. In this talk we will discuss the model specifics, strategies for implementation and modification for different classroom settings, as well as student outcomes and feedback regarding this learning process.

Session JD: PER: Diversity, Equity & Inclusion III

Location: CC: Grand Gallery A **Sponsor:** Committee on Research in Physics Education
Time: 10:20–11:20 a.m. **Date:** Wednesday, July 13 **Presider:** TBA

JD01 (10:20 to 10:30 AM WEDNESDAY) Equity in Student Equipment Usage for Remote and In-Person Labs

Contributed – Presenting Author: Matthew Dew, Cornell University

Additional Author | Anna M Phillips, Tufts University

Additional Author | Samuel Karunwi, Cornell University

Additional Author | Ariel Baksh, Cornell University

Additional Author | N. G. Holmes, Cornell University

Introductory laboratory (lab) courses are one of the first opportunities students have to become familiar with experimental physics. An important part of this experience is getting to work hands-on with an array of physics equipment. Previous studies have shown, however, that women may have more limited access to equipment in labs. This difference could easily be exacerbated or alleviated with the shift to remote learning during the COVID-19 pandemic. We analyzed video recordings of students in two implementations of an introductory lab course, one taught in-person and one taught remotely, to quantify students' equipment use. We found that remote labs created a more gender equitable learning environment for students. In this talk, I will discuss possible explanations and the implications for lab course design.

JD02 (10:20 to 10:30 AM WEDNESDAY) Developing a Python tool to Categorize Motivation of Undergraduate Women

Contributed – Presenting Author: Maxwell Franklin, Drexel University

Additional Author | Eric Brewe, Drexel University

Additional Author | Annette Ponnock, Yale University

We previously created a coding scheme, based in expectancy-value and self-efficacy theories, to categorize the reasons undergraduate women joined physics. However, this coding is arduous for large datasets, so we have built a Python tool that takes a survey response asking about motivation as input and outputs the proportion of each motivational code in the response. Preliminary testing of this program showed an accuracy rate of 74 percent, when compared to hand-coding. This allows short answer survey data to be categorized relatively quickly. We plan to use this to correlate motivation, along with other survey data, with retention in order to build a full predictive tool for undergraduate retention. In this talk, we will discuss the development of our tool and the methods used to validate it, as well as the theory around natural language processing and thematic analysis in education research.

JD03 (10:30 to 10:40 AM WEDNESDAY) Identifying Academic Ableism: Case Study of a UDL-Learning Community Participant

Contributed – Presenting Author: Camille Coffie, University of Central Florida

Additional Author | Westley James

Additional Author | Jacquelyn J Chini, University of Central Florida

In this talk, we analyze an interview with a physics instructor who was participating in a year-long learning community about incorporating Universal Design for Learning (UDL) in active-learning postsecondary STEM courses. In doing so, we respond to Dolmage's (2017, pg.31) challenge, echoing Foucault, that since "ableism is everywhere… we are responsible for looking for it, recognizing our role in its circulation, and seeking change". While physics may masquerade as a "culture of no culture", individuals' experiences in physics are shaped by the same systems of oppression that operate in the larger society. While this instructor was actively participating in professional development about UDL, a framework to proactively design instruction to support variation in students' needs, abilities, and interests, we identify examples of how their beliefs about students, teaching, learning, and physics are shaped by ableism. These insights highlight the importance of confronting ableism in promoting inclusion in STEM education.

JD04 (10:40 to 10:50 AM WEDNESDAY) Inclusiveness of Learning Environment Mediates Gender Differences in Learning Outcomes

Contributed – Presenting Author: Yangqiuting Li, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

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 longitudinal study on students' motivational beliefs and grades in a two-term college calculus-based introductory physics sequence to investigate how students' perception of the inclusiveness of learning environment predicts students' self-efficacy, interest, identity and grades. 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.

JD05 (10:50 to 11:00 AM WEDNESDAY) To Whom do Students Believe a Growth Mindset Applies?

Contributed – Presenting Author: Alysa Malespina, University of Pittsburgh

Additional Author | Chandralekha Singh, University of Pittsburgh

In this study, we validated an intelligence mindset survey and investigated mindsets of students in introductory physics courses. Validation showed that students can have different intelligence mindsets for themselves and others. As a result, we separated mindset into self-focused and other-focused categories. Self-focused mindset survey items better predicted course grades than other-focused items. Post-semester surveys showed a decrease in growth-mindset scores compared to the pre-semester surveys.

JD06 (11:00 to 11:10 AM WEDNESDAY) Planning for Participants' Varying Needs and Abilities in Qualitative Research

Contributed – Presenting Author: Daryl McPadden, Michigan State University

Additional Author | Paul W Irving, Michigan State University

Additional Author | Jacquelyn J Chini, University of Central Florida

Additional Author | Erin M Scanlon, University of Connecticut

Additional Author | Vashti Sawtelle, Michigan State University

All people vary in their needs, abilities, and interests; however, typical research practices do not consider these variations, which likely impacts who participates in research studies. In this talk, we will demonstrate how a model of individual variation can be used to anticipate variation in research participants' needs. Using that model, we will highlight how different qualitative interview formats (a typical oral interview, an asynchronous written interview, a socially supported interview, and a focus group) might require different participant strengths. We then present a study using these interview formats and explore how participants with disabilities experienced the different formats. Through this study, we hope to demonstrate how researchers can better anticipate a variety of participant needs and how researchers can design alternative formats of data collection to better include the experiences of students with disabilities in qualitative research studies.

Session JE: PER: Student Content Understanding, Problem-Solving and Reasoning VI

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Research in Physics Education
Time: 10:20–11:20 a.m. **Date:** Wednesday, July 13 **Presider:** TBA

JE01 (10:20 to 10:30 AM WEDNESDAY) Perspectives on Evaluation Strategies

Contributed – Presenting Author: Abolaji Akinyemi, University of Minnesota, Duluth

Additional Author | Michael E Loverude, California State University, Fullerton

Additional Author | John R Thompson, University of Maine

One expected outcome of physics instruction is that students develop quantitative reasoning skills, including strategies for evaluating solutions to problems. Examples of evaluation strategies include special case analysis, unit analysis, and checking for reasonable numbers. To investigate students' use of evaluation strategies, we developed and administered tasks prompting students to evaluate symbolic expressions, including the electric field due to three point charges, the velocity of a block at the bottom of an incline with friction, and the final velocities of two masses involved in an elastic collision. Written and interview data were collected at the introductory, sophomore, and junior levels. We classified students' evaluation strategies into three broad categories: consulting external sources, checking through computation, and comparing to the physical world. We compare our categories to prior work in PER and examine the categories through theoretical lenses of epistemic frames, mathematical modelling, proofs and justifications, and metacognition.

JE02 (10:30 to 10:40 AM WEDNESDAY) Observations of Student Resources in Introductory Programming Tutorials

Contributed – Presenting Author: Austin Anderson, Department of Physics, University of North Florida

Presenting Author | Paige Pressler, Department of Physics, University of North Florida

Additional Author | W. Brian Lane, Department of Physics, University of North Florida

The use of computation in undergraduate physics education is on the rise, but this implementation faces the challenge of attending to students' varied degrees of experience with programming. To explore how students approach learning a new programming language, we employ the resources framework, which posits that students approach new learning situations by making use of information or skills (resources) they have

already developed. We designed a series of introductory Python tutorials and conducted think-aloud interviews to identify the resources that students activated while completing the tutorials. We present a preliminary analysis of two extreme cases: a student with a rich mathematical background and no programming experience, and a student with a moderate mathematical background and a rich programming experience in multiple programming languages outside of Python. These observations will help inform the further development of these tutorials to explicitly activate helpful resources.

JE03 (10:40 to 10:50 AM WEDNESDAY) Relating Computational Thinking Practices and Problem Design Features

Contributed – Presenting Author: Theodore Bott, Michigan State University

Additional Author | Tyler Stump, Michigan State University

Additional Author | Paul W Irving, Michigan State University

Additional Author | Daryl R McPadden, Michigan State University

With the growing ubiquity of computation in STEM fields, understanding how to teach computational thinking (CT) practices has become an active research area in the last two decades, with particular emphasis on developing CT frameworks. In this paper, we apply one of these CT frameworks and correlate the results with a task analysis to examine how CT practices relate to specific design features of an in-class problem. We have analyzed video data from two separate groups working on one computational class period, which utilizes a minimally working program to model magnetic field vectors. While still in the initial stages of the study, our preliminary results indicate that what is left out of the minimally working program will impact the CT practices students use, particularly around building computational models. Ultimately, we hope this work will help instructors to design activities that can target & build specific CT practices.

JE04 (10:50 to 11:00 AM WEDNESDAY) Leveraging Dual-Process Theories to Improve Student Reasoning About Air Resistance*

Contributed – Presenting Author: Drew Rosen, University of Maine

Additional Author | MacKenzie R. Stetzer, University of Maine

Additional Author | Beth A. Lindsey, Penn State Greater Allegheny

Additional Author | Andrew Boudreaux, Western Washington University

On qualitative physics questions, students often reason on the basis of context-specific heuristics rather than systematically applying broader principles. In ongoing work, we have used dual-process theories of reasoning (DPToR) to account for student reasoning patterns on such questions. In this talk, we describe an intervention designed to improve student reasoning about the terminal speed behavior of falling objects. In the intervention condition, students were prompted to reconcile highly available ideas about the drag force with a Newton's second law analysis. This intervention was intended to simulate a sustained, productive engagement of the analytic process. In the control condition, students received additional practice applying the normative Newton's second law reasoning in slightly different contexts. After the intervention, the treatment group's performance was statistically significantly stronger than that of the control group. We are currently working to adapt this intervention to other contexts to promote more productive and flexible physics reasoning.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

JE05 (11:00 to 11:10 AM WEDNESDAY) Adapting a Dual-Process Informed Intervention Strategy Across Content Domains*

Contributed – Presenting Author: Andrew Boudreaux, Western Washington University

Additional Author | Beth A. Lindsey, Penn State University - Greater Allegheny

Additional Author | Drew J. Rosen, University of Maine

Additional Author | MacKenzie R. Stetzer, University of Maine

In an ongoing project, we have been using dual-process theories of reasoning to make sense of student difficulties and guide the design of instruction. A focus has been on qualitative tasks in which students give a quick answer, based on an intuitively appealing model, that contradicts physics principles emphasized in their course. We have recently found some success with a HW-based intervention to address a persistent difficulty with air resistance (see Rosen et al., this meeting), and are trying to adapt the intervention to a different content domain. An overarching goal is to identify domain-general curriculum development strategies based on dual process theories. Our target domain involves the balancing of extended objects – and the documented belief that the center of mass divides an object into two pieces of equal mass. In this talk, we describe the intervention strategy, as implemented in the balancing context, and share assessment data.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

JE06 (11:10 to 11:20 AM WEDNESDAY) How Often Can Students Co-construct Knowledge in Quantum Mechanics?

Contributed – Presenting Author: Mary Brundage, University of Pittsburgh - Pittsburgh, PA

Additional Author | Alysa Malespina, University of Pittsburgh - Pittsburgh, PA

Additional Author | Chandralekha Singh, University of Pittsburgh - Pittsburgh, PA

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.

Session JF: Sports Meets Physics II

Location: CC: Grand Gallery F **Sponsor:** Committee: Committee on Educational Technologies
Time: 10:20–11:20 a.m. **Date:** Wednesday, July 13 **Presider:** Andre Bresges

JF01 (10:20 to 10:30 AM WEDNESDAY) Hitting the Chains: Disc Golf Physics

Contributed – Presenting Author: Joseph Johnson, Mercyhurst University

Additional Author | Paul G Ashcraft, Mercyhurst University

Additional Author | Bradley W Treece, Mercyhurst University

The sport of disc golf is among the fastest growing sports in the world today. Through the pandemic, the number of players has exploded. Physics explains many aspects of the sport, from the throwing motion, the flight of the disc, to the final hitting the chains to spread the disc's impulse out over time so the disc drops into the basket. Whether conceptual, algebra-based or calculus-based introductory, or even upper-level fluid dynamics courses, video analysis of disc golf and data-based examples offer concrete examples of various physical concepts. Examples of video analysis and classroom uses will be shown.

JF02 (10:30 to 10:40 AM WEDNESDAY) Biomechanics Replacing Mechanics

Contributed – Presenting Author: Nancy Beverly, Mercy College

In our Introductory physics for life science course, students learn mechanics in the context of biomechanics, using data from their own bodies as much as possible with use of video analysis, 2D force plates, and goniometers. Students relate their body and limb motion to the forces they exert on their environment and the forces their muscle exert on their limbs. Movements are analyzed as sequences of simple segments, with focus on crucial or high force moments. As most of these students are interested in careers in health, caloric expenditure and stress and strain on tissues are included. Students are encouraged to explore movements of interest to them, which often are related to sports or injury prevention with proper technique.

JF03 (10:40 to 10:50 AM WEDNESDAY) Swords for Science

Contributed – Presenting Author: Melissa Vigil, Marquette University

In the fall of 2021, the Marquette University Honors Engineering Physics Class worked together with the Wandering Sword Project to measure the center of mass and moment of inertia for a variety of straight and curved swords. and pole-weapons. Results were compared to student work from previous semesters where the same methods were used to analyze other sporting equipment such as golf-clubs, baseball bats, and hurly sticks.

JF04 (10:50 to 11:00 AM WEDNESDAY) Gutterballs, Lip Outs, and Swirlies

Contributed – Presenting Author: Keith Zengel, Wentworth Institute of Technology

A ball placed inside a hollow cylinder and spun around an axis perpendicular to the cylinder wall will roll back and forth along the cylinder wall, as expected, but it will also oscillate along the axial direction of the cylinder. These axial oscillations occur in horizontal, tilted, and even vertical cylinders. Here the connections of this system to the sports of bowling (gutterballs), golf (lip outs), and basketball (swirlies) are presented, along with ideas for video analysis experiments for undergraduate level physics labs.

PLENARY III: Douglas Duncan - Run a 2023 And 2024 Eclipse Event at Your School, for Fun, Education, and Profit!

Doug Duncan

In Oct. 2023 and April 2024 two spectacular eclipses of the sun will cross the US. Every state will see a partial eclipse, and over 30 million people are in the path of the total eclipse. Your school and community will be very thankful if you organize safe eclipse watching. At the same time, if you plan, this can be a great fundraiser, if you make safe eclipse-watching glasses available.My small campus museum made $10,000 each of the last two American eclipses, by announcing to our community that we had glasses and information about eclipse viewing. For one eclipse, we got the stands of the football field open for us, and 10,000 people attended! (see the photo) As a veteran of 12 total eclipses since 1970, Dr. Duncan is an expert on eclipse logistics, planning, and science.

(https://casa.colorado.edu/~dduncan/?page_id=114) He is also a former staff member of the Hubble Space Telescope, and a science commentator on National Public Radio.

AAPT PHYSICS EDUCATION

Wednesday, July 13

11:30 a.m.–12:30 p.m.

Hotel: Ambassador Ballroom

Session KA: Diversity, Equity, and Inclusion: Physics Education and Identities

Location: CC: Grand Gallery A **Sponsor:** Committee on Diversity in Physics
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** Alexis Knaub

KA01 (12:40 to 12:50 PM WEDNESDAY) Critical Path Analysis of High School Student Physics Identity*

Contributed – Presenting Author: Benjamin Archibeque, Florida International University (FIU)

Additional Author | Pooneh Sabouri, Florida International University (FIU)

Additional Author | Joinee Taylor, Florida International University

Additional Author | Geoff Potvin, Florida International University

Additional Author | Zahra Hazari, Florida International University

Underrepresentation in physics is rampant across gender and minoritized ethnic/racial (MRE) groups. Understanding factors which may contribute to it and proposing remedies are valuable to rectify it. Looking at quantitative data through a critical theory lens allows us to reveal systemic inequities, interrogate 'facts,' and pose competing models/interpretations. We will present a pathway analysis of student physics identity using survey data collected from 1979 students in Fall 2018 from 16 high school physics classes across three regions of the US with an oversampling of MRE groups. Results mostly reveal similarities in pathways between groups. However, we see significant differences in identity constructs which suggest persistent inequities between populations. We argue that the differences in constructs are indicative of the enforcement/adoption of systemic structures which do not suit all students.

*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

KA02 (12:50 to 1:00 PM WEDNESDAY) Education Research on Un-grading

Contributed – Presenting Author: Benjamin R. Petkie

Un-grading is a method used in education that focuses on formative feedback. For example, many Un-graded courses have students set learning goals at the beginning and check in with the professor throughout. At the end of the course students are assigned a grade based on their learning goals. At our institution there are ongoing efforts to implement Un-grading in STEM courses, including introductory physics. Here, I present preliminary findings from qualitative research on these efforts. Students and instructors from three different courses utilizing this method were interviewed and the transcripts analyzed to identify benefits and drawbacks of Un-grading. The results of this study suggest Un-grading has a variety of benefits over traditional grading scales. For example, students felt Un-grading allowed them to learn in a style and pace that worked for them. The study also suggests ways to improve its effectiveness.

KA03 (1:00 to 1:10 PM WEDNESDAY) Documenting the Impact of HSIs on Physics and PER

Contributed – Presenting Author: Brianne Gutmann, San José State University

Additional Author | Rebecca Rosenblatt, National Science Foundation

Hispanic serving institutions (HSIs) are an increasingly large set of higher education institutions. From 2010-2020 the number of HSIs went from 311 to 569. Within the PER community, research perspectives from HSIs have provided critical insights into how to support racially and ethnically diverse students in physics education. This presentation will build on work presented at the Winter 2022 AAPT meeting that investigated the number of physics education researchers at HSIs, the fraction of HSIs that have physics education researchers, and demographic data on publications from HSIs. In this presentation we will analyze data from IPEDS providing information about how HSIs contribute to the diversity of undergraduate and graduate physics students. In addition, we will examine themes from publications at HSIs to highlight how physics education researchers center their HSI's unique student population in their research and what ways these unique populations advance physics education research.

KA04 (1:10 to 1:20 PM WEDNESDAY) Description of Experimental Features of Creating A Gradient Palladium-Hydrogen Alloy*

Contributed – Presenting Author: Olena Lyubimenko, Donetsk National Technical University, Sq. Shibankova 2a, 85302, Pokrovsk, Ukraine

Research of the experiment on measuring the bending arrow of a cantilever fixed palladium plate. The experiments were carried out in a hydrogen-vacuum plant at a temperature of 280 ° C, a change in pressure in the working chamber of the plant, and an increase in the hydrogen concentration in palladium. It has been experimentally recorded that the bending of a palladium plate upon additional saturation with hydrogen consists of two stages. It was experimentally shown for the first time that at 280 ° C the maximum plate bends decrease with an increase in the hydrogen concentration in palladium by the same amount at each puffing. The kinetics of the straightening process is the same and the plate bends are reversible.

*It was established for the first time that thickness of a gradient α-PdHn alloy depends on the hydrogen content in palladium.

KA05 (1:20 to 1:30 PM WEDNESDAY) Political Disability Identity: A Framework for Physics Education Research

Contributed – Presenting Author: Liam McDermott, Rutgers University (New Brunswick)

Disability is a unique and multifaceted identity. It is made political simply by existing in the body and the mind of a disabled person. In a climate charged with politicality and identity discourse in the classroom, a framework for understanding disability and the transactional relationship disabled persons have with their environment in a political way is needed in physics education research. In this talk, I will introduce a framework scarcely used in education, Political Disability Identity (PDI). This framework is useful for understanding disability identity development in the physics classroom. I will discuss its utility in education research, particularly physics education research.

KA06 (1:30 to 1:40 PMWEDNESDSY) Building Physics Identity in Informal Spaces: Communities of Practice Applications

Contributed – Presenting Author: Brean Prefontaine, Michigan State University

Additional Author | Kathleen Hinko, Michigan State University

Past research work has focused on operationalizing the Communities of Practice framework to understand physics identity development among those who facilitate within informal physics spaces. This work has helped researchers better understand how informal physics experiences provide room for people to develop physics identities which are important for persistence within the field. Furthermore, research has shown that students who feel as though they need to give up their other identities, culture, femininity, etc. will not continue to stay within physics. Using the Communities of Practice theory has proven to be useful in understanding how to support multiple identities of students in informal physics groups. In this talk, we aim to explore how the Communities of Practice approach to informal physics

spaces can be a useful tool for practitioners. Implications from the research will be discussed, including possible future considerations and uses for the framework during program development and revisions.

KA07 (1:40 to 1:50 PM WEDNESDAY) The Sesquicentenary of David Unaipon (1872-1967): a First Australian scientist

Contributed – Presenting Author: William Palmer, Adjunct Curtin University

David Unaipon was born one hundred and fifty years ago on 28th September 1872 at the Point McLeay Mission, South Australia. His father, James Ngunaitponi worked as an evangelist at the mission. He was educated at the mission and then worked as a servant with a kindly man, who encouraged his interests in music and science. He read widely and investigated the problem of perpetual motion. As a result of these investigations, he came up with nineteen patented devices. He lacked the financial resources to develop the patents, so never earned any money from them. One of his inventions, a device to shear sheep, was manufactured successfully. He also was a very competent writer and collected traditional Aboriginal stories, which were published without naming him as the author. David Unaipon died on 7th February 1967, and his portrait decorates the Australian fifty dollar banknote.

Session KB: Introductory Courses, Introductory Labs/Apparatus

Location: CC: Grand Gallery F **Sponsor:** AAPT
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

KB01 (12:40 to 12:50 PM WEDNESDAY) Flipped vs. Traditional IPLS: Controlling the Control Variables

Contributed – Presenting Author: Dean Richardson, Xavier University of Louisiana

The first semester of the Introductory Physics for Life Science majors was taught in the flipped format. At the same time, a traditional section was taught by the same professor. Common exams were used each semester. The results are discussed, and a direct comparison can be made. Unfortunately, it isn't clear which format did better. One semester one format did better, the next semester the other format did better. The question now is whether all of the necessary control variables are being controlled. Sometimes it is difficult to simply identify all of things that affect the results.

KB02 (12:50 to 1:00 PM WEDNESDAY) CourseSource Physics: A New Practitioner Journal for Physics Educators

Contributed – Presenting Author: Andy Rundquist, Hamline University

Additional Author | Melissa Dancy, University of Colorado

CourseSource Physics provides physics educators a place to publish their successful teaching practices and to engage in a community of fellow educators. Do you have a single lesson, unit, or whole class that's working well with student learning evidence to show it? This is the journal for you! I'll talk about our philosophy, our structure, and how you can get involved.

KB03 (1:00 to 1:10 PM WEDNESDAY) Next Gen PET in a Lecture-Lab Format!*

Contributed – Presenting Author: Gay Stewart, West Virginia University

Additional Author | Paul Miller, West Virginia University

Additional Author | Lynnette Michaluk, West Virginia University

Adapting Next Gen PET, an NSF-funded Engaged Student Learning project, sought to address two persistent problems in undergraduate education: the challenge of effective teaching resulting in useful learning in large lecture formats and the challenge of developing scientific understanding of physics principles by pre-service elementary teacher candidates. The goal was to provide a framework to both improve physics learning for future teachers and empower faculty to implement education research in their physics courses by providing a well-tested and refined version of the curriculum that fits the most widely used general education science class model (lecture and lab). We also sought to add the one science practice not emphasized in the PET curriculum, planning and carrying out investigations. These new curriculum resources and their impact on instructor evaluation and student learning will be presented.

*This work funded in part by the Adapting the Next Generation Physical Science and Everyday Thinking Curriculum for a Lecture-Laboratory Format grant from the NSF, DUE-1611738.

KB04 (1:10 to 1:20 PM WEDNESDAY) Modeling Ring Magnets: Non-linear, Damped Oscillators

Contributed – Presenting Author: Maggie Brewer Sherer, William Jewell College

Ring magnets interacting along a dowel rod provide a simple system for exploring oscillating systems beyond those with a linear restoring force. Using measurements from slow motion video, coupled with computational models of the system, we have developed experiments which can be used both in introductory and upper-level labs. Introductory labs include modelling non-linear forces in static equilibrium and modeling and measuring the period of the damped oscillator. Students then extend these ideas in upper-level labs, including damped-driven oscillators, resonant frequencies, and modeling multi-body systems of three and four ring magnets.

KB05 (1:20 to 1:30 PM WEDNESDAY) A Capacitive Liquid Level Sensor for Application Based Labs

Contributed – Presenting Author: Joseph LaVigne, Saginaw Valley State University

Additional Author | John Potts, Saginaw Valley State University

Additional Author | Matthew D. Vannette , Saginaw Valley State University

Additional Author | Christopher M. Nakamura, Saginaw Valley State University

Connections to engineering applications are becoming increasingly valued in introductory level physics curricula. For both high school and college students taking introductory physics, it is important that they understand both the concepts, and their applications. We present a capacitive liquid level sensor that demonstrates a use of capacitors beyond the usually cited storing of energy. Seeing how design parameters impact its performance in an experiment can demonstrate how devices are designed and optimized, and how students can apply the physics they are learning. Our sensor uses a large parallel plate capacitor and a relaxation oscillator to convert liquid level information to frequency. The frequency at which a lamp in the circuit blinks gives information about how much dielectric is between the plates, and thus the liquid level. This demonstrates how a capacitor could be used in an engineering context to make useful measurements.

KB06 (1:30 to 1:40 PM WEDNESDAY) Student Outcomes from a Remote, Large Enrollment, Course-based Undergraduate Research Experience

Contributed – Presenting Author: Heather Lewandowski, University of Colorado

Additional Author | Alexandra Werth, University of Colorado

Additional Author | Colin West, University of Colorado

Recently, course-based undergraduate research experiences (CUREs) have been recognized as a way to improve STEM lab education by engaging students in authentic discovery. CUREs have been shown to have positive benefits similar to traditional undergraduate research experiences and can allow all students enrolled in a class the opportunity to participate in research. In response to the need to go fully remote because of the COVID-19 pandemic, we designed and implemented the first remote, large-enrollment, physics CURE. We report on the course structure and components, as well as initial research into the student outcomes. We find that this course helped students gain research skills and coding confidence, engage in productive and enjoyable teamwork experiences, and feel motivated and interested in experimental physics research.

Session KC: PER: Student and Instructor Support & Professional Development, Program and Institutional Change III

Location: CC: Grand Gallery B **Sponsor:** Committee on Research in Physics Education

Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

KC01 (12:40 to 12:50 PM WEDNESDAY) Identifying Learning Assistants' Resources for Student-Centered Teaching*

Contributed – Presenting Author: Anne Alesandrini, University of Washington

Additional Author | Rachel E Scherr, University of Washington

Additional Author | Lisa M Goodhew, Seattle Pacific University

The practice of eliciting, valuing, and building on student ideas is central to several research-based teaching strategies, including responsive teaching and resource-oriented instruction. Attending to student thinking and using student ideas as instructional assets can be a challenge for novice instructors, and so we investigate the ideas from which these practices are built in order to better support novice instructors' growth as teachers. Here, we apply a conceptual resources framework to identify Learning Assistants' (LAs') resources for student-centered instruction. We identify productive ideas about teaching that are voiced by multiple LAs and reoccur in the LA pedagogy courses at two universities. This talk will present examples of LAs' resources for teaching that may be elicited, promoted and built upon to support LAs in enacting student-centered practices, ultimately improving physics instruction for the students they teach.

*Supported in part by NSF DUE-1914572

KC02 (12:50 to 1:00 PM WEDNESDAY) A Paradigm of Repair for Group Work in Introductory Labs

Contributed – Presenting Author: Katie Ansell, University of Illinois Urbana-Champaign

As educators, we value students' ability to work in groups and often ask them to do so in class. Students desire "good" group dynamics, yet various factors can lead to disappointing outcomes, including inequitable distribution of labor or the exclusion of minoritized students. Teaching staff, particularly novice Teaching Assistants (TAs), may not notice group dynamic issues, nor have they been trained to prevent or resolve them. In this talk, I will propose a view of conflict as a natural part of working in groups, and therefore something we can equip our students and teaching teams to navigate and repair. This talk will provide examples of recent classroom interventions with students and instructional staff under this social-emotional paradigm in a large-enrollment introductory laboratory setting. Results from early iterations of these interventions will be presented along with our next steps in this work.

KC03 (1:00 to 1:10 PM WEDNESDAY) Identifying Epistemic Frames in Faculty Discourse Centered around Ethics

Contributed – Presenting Author: Bill Bridges, Kansas State University

Additional Author | Tyler Garcia, Kansas State University

Additional Author | Caleb Linville, Kansas State University

Additional Author | Wyatt Jones, Kansas State University

Additional Author | Caitlin Solis, Kansas State University

Scientists are encouraged to engage in some form of ethical training. A common criticism of these training modules is that they are not effective. We formed a fellowship of fifteen scientists to investigate different modes of engagement with value-laden topics to see how scientists would engage in more ethically-driven discussions. These scientists met for a series of group sessions over the course of an academic year. We examined these discussions through the lens of epistemic frames, and characterize these frames through a number of characteristics including behaviors, verbal cues, and epistemic forms. We use these characteristics to identify the frames present in the fellowship, and what factors influenced changes in frames. Categorizing discussions with epistemic frames offers an opportunity for identifying what is driving more ethically-minded discussions, and this knowledge could then be used to better design ethical training modules.

KC04 (1:10 to 1:20 PM WEDNESDAY) Student Perspectives of Mini-Studio GTAs' Roles in Resolving Group Challenges

Contributed – Presenting Author: Constance Doty, University of Central Florida

Additional Author | Tong Wan, Westminster College

Additional Author | Ashley A Geraets, University of Central Florida

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

Additional Author | Jacquelyn J Chini, University of Central Florida

The use of groupwork in physics tutorial and lab sections presents opportunities for students to learn from each other as they make sense of physics and develop critical thinking skills. However, the same opportunities might leave students vulnerable to their ideas being negatively judged by their peers, creating a negative learning experience. GTAs who lead such courses might use strategies to help students resolve their group dynamic challenges to mitigate negative social interactions. In this study, we analyze interviews with fourteen students who were enrolled in Physics I/II mini-studio sections (combined tutorial and lab) to investigate group dynamic challenges they experienced and their GTA's actions to resolve those challenges. Then, we explore a potential relationship between students' perceptions of their GTA as an instructor or mentor with their evaluation of the GTA's success with helping to resolve their group dynamic challenges. Finally, we discuss implications for GTA professional development.

KC05 (1:20 to 1:30 PM WEDNESDAY) The Effect of Value-Focused Discussions on Scientists' Ethical Decision Making

Contributed – Presenting Author: Tyler Garcia

Additional Author | Bill Bridges

Additional Author | Caleb Linville

Additional Author | Caitlin Solis

Additional Author | Wyatt Jones

Additional Author | Scott Tanona,

Additional Author |Jonathan Herington

Additional Author | James T. Laverty

Current ethics training shows little improvement in ethical decision making. Recent studies have shown that values play a much bigger role in science than what is normally accepted. We believe that by having discussions about the values found in decisions in science, we can improve scientists' ethical decision making. We are measuring better ethical decision making by seeing how scientists' awareness of ethical values and level of moral reasoning changed. We formed a fellowship of fifteen science faculty where they discussed the values embedded in various scientific norms to bring awareness to the values inherent in research practices. In order to see how the fellowship impacted the scientists' ethical reasoning, we conducted pre/post interviews where we asked "what would you do" in different ethical vignettes. We determined that scientists' identified more values and we are still looking at their ethical reasoning.

Session KD: PER: Student Content Understanding, Problem-Solving and Reasoning V

Location: CC: Grand Gallery E **Sponsor:** Committee on Research in Physics Education
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

KD01 (12:40 to 12:50 PM WEDNESDAY) Making Expert Processes Visible: How and Why Theorists Use Analogy

Contributed – Presenting Author: Mike Verostek, University of Rochester

Additional Author | Molly Griston, University of Rochester

Additional Author | Jesus Botello, The University of Texas at Austin

Additional Author | Benjamin M Zwickl, Rochester Institute of Technology

Understanding how physicists solve problems can guide the development of methods that help students learn and improve at solving complex problems. Leveraging the framework of cognitive task analysis, we conducted semi-structured interviews with theoretical physicists (N=11) to gain insight into the cognitive processes and skills that they use in their authentic research. Among numerous activities that theorists described as integral to their work, here we elucidate how theorists utilized analogies. We found that theorists used analogies to generate new project ideas as well as overcome conceptual challenges. Theorists deliberately sought out or constructed systems to use as a source of knowledge, indicating this is a skill students can practice. When mapping knowledge from one system to another, theorists sought to use systems that shared a high degree of mathematical similarity; however, these systems did not always share similar surface features. We conclude by offering potential applications to instruction.

KD02 (12:50 to 1:00 PM WEDNESDAY) Challenges and Successes in Reconciling Different Ideas During Group Work

Contributed – Presenting Author: Muxin Zhang, University of Illinois Urbana-Champaign

Additional Author | Samuel Vance, University of Illinois Urbana-Champaign

Additional Author | Matt Massari, University of Illinois Urbana-Champaign

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

One idealized view of collaborative problem solving is that students with different understandings of a problem can learn by sharing their ideas and discussing them. In this study, we analyzed videos of group work to understand how discussing and reaching shared understanding of different ideas during collaboration can be challenging and how it can be successful. We found that, in cases when a group fails to reconcile different ideas, each student defends their own line of reasoning and may even epistemologically reject another way of thinking. By contrast, in a case when students reach a group resolution, students respond to each other's reasoning and establish a common ground that incorporates different lines of reasoning. We will discuss connections to existing models of collaboration and potential implications for facilitating group work.

KD03 (1:00 to 1:10 PM WEDNESDAY) Investigating Introductory Student Difficulties Reading Electric Field Diagrams

Contributed – Presenting Author: Raymond Zich, Illinois State University

Additional Author | Naomi Satoh, Illinois State University

This study investigated student difficulties reading electric field diagrams and the effect a visual change to these diagrams had on students' ability to interpret these diagrams. Electric field diagrams are often drawn with a uniform line thickness and color. We modified the electric field diagrams to use variations in line thickness, line continuity, and arrow shape to indicate the strength and direction of the electric field. These changes, which are consistent with theories of visual attention and grounded cognition, exploit students' innate ability to perceive line variations and arrow styles to communicate the electric field strength and direction. Students were randomly assigned to compare electric field strength and direction for points on traditional or modified diagrams. Results show correctness gains of 12.3% for magnitude and gains of 7% for direction using the modified diagrams. Overall correctness gains of 10% were observed for the modified over the traditional diagrams.

KD04 (1:10 to 1:20 PM WEDNESDAY) Effect of Guided Retrieval Practice and Feedback on Physics Problem-Solving

Contributed –Presenting Author: Tianlong Zu, Jacksonville State University

Additional Author | Nobel Sanjay Rebello, Purdue University

Problem-solving and long-term retention of knowledge are important goals in physics learning. Retrieval practice, as a method shown to be effective promoting retention of studied material, is seldomly used in physics classroom. This work examines the effect of guided retrieval practice in terms of

questions and feedback in terms of question answers or lecture video summary on college students' problem solving as well as one-week delayed retention performance. We found that students who practiced guided retrieval outperformed those practiced restudy regardless of the type of feedback. The effect is prominent when the problems used on the test are isomorphic to the guided questions during retrieval than when they are transfer questions. Students who just restudied the material also overpredicted their performance compared to the retrieval group. This difference in performance judgment disappeared after seeing the feedback. Overall, we found evidence supporting the effectiveness of retrieval practice in physics learning.

KD05 (1:20 to 1:30 PM WEDNESDAY) Tools and Logic of Problem Solving in Physics

Contributed – Presenting Author: Igor Zubov, Bergen County Academies

"How to start/set up the problem?" "What to do next?" The list can go on and is painfully familiar to virtually all students and not only. If left unanswered, these questions can easily turn students away from Physics, making problem solving a torture rather than fun and disengaging students rather than stimulating them to learn more. The author shares some approaches, methods, and materials that might help in resolving this situation based on 30+ years of learning and teaching Physics at different levels. They have been tested with hundreds of students and proven to help many of them. The material briefly described in this presentation is available for students and teachers. It was published in full last year in a two-part book with the same title.

Session KE: Physics Teaching Around The World

Location: CC: Grand Gallery C **Sponsor:** Committee on International Physics Education
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** Daniel MacIsaac

KE02 (12:50 to 1:00 PM WEDNESDAY) Teaching Energy Through Calorimetry: Insights from Canadian and Israeli Perspectives

Contributed – Presenting Author: Richard Hechter, University of Manitoba

Additional Author | Avraham Merzel, Hebrew University of Jerusalem

Additional Author | Yaron LeHavi, David Yellin College of Education

Striving at fostering positive experiences of secondary level physics teachers in Canada and Israel towards teaching energy as one cross-cutting concept, we applied two approaches of investigative lab-oriented activities in professional development workshops: a holistic approach, and an exhaustive approach. The holistic approach involved teachers investigating various calorimetric experiments centered on developing conceptual understanding through qualitative approaches punctuated with broad quantitative results. The exhaustive approach encouraged teachers to generate understanding through enhancing data collection and resultant measurement precision by innovating modifications to the apparatuses and data collection methods. In this session we will present insights from our workshops focussing on the interactions of the participants with each other, with the physics concept of energy from a calorimetric perspective, and with the curriculum from which they would teach it.

KE03 (1:00 to 1:10 PM WEDNESDAY) Comparing Introductory Physics Courses in the US and China

Contributed – Presenting Author: Juan Yang

Additional Author | James T. Laverty, Kansas State University

Additional Author | Eleanor C. Sayre, Kansas State University

We investigate the different cultures of introductory university physics pedagogy of the United States and China through case studies at Kansas State University and Chongqing Jiaotong University. We look at the effects of different educational system backgrounds, social and cultural backgrounds, university systems and student characteristics on teaching status and pedagogy. In the US, the introductory physics curriculum pays more attention to quantitative reasoning and ethical significance of science, while that of China emphasizes the results and the materialistic worldview more. These differences are supported by greater resources in teaching time, lecture demonstration development, and supporting students' learning. However, these increased resources in the US also lead to more diversity of teaching methods and increased efforts to assess students. We close with suggestions for improving the general education of physics in the universities of the two countries.

KE04 (1:10 to 1:20 PM WEDNESDAY) Teaching Physics in Sub-Saharan Africa

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

Additional Author | Godwin Kwame Aboagye, University of Cape Coast, Ghana

The authors will share about their experiences teaching in Zimbabwe, Malawi, and Ghana. Dean Stocker taught Forms 1 - 4 Science and Maths in a rural Government Secondary School in Zimbabwe as a US Peace Corps Volunteer. He was also a lecturer in the physics department at Mzuzu University in Malawi, teaching introductory physics, mechanics, and solid state physics. Godwin Aboagye is a Senior Lecturer at the Department of Science Education, Faculty of Science and Technology, University of Cape Coast in Ghana, where he has been teaching since 2008. The authors will also share their thoughts on exploring the use of active learning in physics courses in Ghana.

Session KF: Teaching & Supporting Future Teachers Using Next Gen PET

Location: CC: Grand Gallery Overlook A/B **Sponsor:** AAPT
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

KF01 (12:40 to 1:10 PM WEDNESDAY) Emergent Outcomes from a Faculty Online Learning Community*

Invited – Presenting Author: Edward Price, California State University San Marcos

"I did not realize [it] was missing from my life." The Next Generation Physical Science and Everyday Thinking Faculty Online Learning Community (NextGen-PET FOLC) was created to support faculty teaching the NextGenPET curriculum. Since 2017, fifty adopters of NextGenPET have met regularly in small groups by videoconference to discuss practical issues, teaching strategies, and student learning. The FOLC provides a sounding board for ideas, space to share experiences and challenges, affective support, and a venue for troubleshooting. The opening quote is one participant's description of the value of talking with others about their teaching. Beyond immediate impacts on their NextGenPET teaching, faculty participants have described significant professional growth, a sense of community, engaging in educational research, and increasing their leadership roles. This talk will discuss the development and evolution of the FOLC, describe emergent faculty outcomes, and offer lessons for other faculty development efforts.

*This work is supported by NSF grant 1626496

FK02 (1:10 to 1:40 PM WEDNESDAY) The NextGenPET Curriculum and Beyond: Integrating the Sciences

Invited – Presenting Author: Nicole Gugliucci, Saint Anselm College

The Next Generation Physical Science and Everyday Thinking curriculum has been developed through years of research and development to teach physical science to pre-service elementary school teachers and other non-science major undergraduates. I will give an overview of the curriculum and the breadth of topics in physics and chemistry that it explores. This curriculum design has been extended to other areas of science with "Life Science and Everyday Thinking" and "Matter and Energy in Earth Systems," though neither has a corresponding faculty online learning community. I will describe how, in a hybrid environment (lectures and labs), and using common threads such as energy conservation, an integrated science course has been created that prepares students for their elementary education certification in a way that is inquiry-based, prioritizes active learning, and provides students with the tools to continue their own scientific learning as they become in-service teachers.

KF03 (1:40 PM to 1:50 PM WEDNESDAY) Engaging Exams: Using Student Interviews and Engineering Design for Assessments

Poster – Presenting Author: Jennifer Snyder, San Diego Mesa College

While courses were remote, all instructors had to come up with innovative ways to assess student understanding that would be authentic and combat academic dishonesty. The NextGen PET curriculum already includes Teaching and Learning and Engineering Design Activities. In Teaching and Learning Activities, students interview others about their understanding of key ideas and phenomena. Engineering Design Activities ask students to create design solutions to problems. This poster discusses how these activities were used in Exams to provide opportunities for students to show their understanding of concepts and models in ways that are engaging to the student.

KF04 (1:50 to 2:00 PM WEDNESDAY) Adult Learning in a Pre-service Content course: Too Soon?

Poster – Presenting Author: Steven Maier, Northwestern Oklahoma State University

The NextGen PET curriculum offers ample opportunities and pathways for meaningful learning. While this includes opportunities for learning content as a student, it includes opportunities for learning in "teacher hat" as a future educator as well. The premise usually held is that pre-service teachers begin coursework in college with sets of assumptions and expectations that are generally based on their K-12 experiences, rooted in pedagogy. Then, by graduation these same students should be better positioned to operate as adult learners. The question is: at what point and by what means should our instructional modes shift to accommodate our students as adult learners? Is a content course taken early in one's academic career too soon? This poster summarizes ongoing work investigating the nature of the transition from pedagogy to andragogy within a studio style implementation of NextGen PET curriculum.

KF05 (2:00 to 2:10 PM WEDNESDAY) Student Resilience in COVID: Advantages of a Hybrid Adaptation*

Poster – Presenting Author: Paul Miller, West Virginia University

Additional Author | Gay Stewart, West Virginia University

Additional Author | Lynnette Michaluk, West Virginia University

The Next Generation Physical Science and Everyday Thinking (NextGen PET) is a proven research-based curriculum that centers the Next Generation Science Standards (NGSS) and has been shown to significantly impact both future teacher content knowledge and understanding of how students learn science. In a recent project*, we developed a hybrid lecture-lab implementation of existing materials and wrote new materials that targeted the NGSS scientific practice of Planning and Conducting Investigations (PCI). Then COVID hit. In this talk, we report on how this recent format change helped us manage the shift online. The students were resilient, based on their course evaluation comments. We examine whether their content learning, attitudes changes, and knowledge of PCI (using materials developed for this purpose) was as resilient with data from before, during, and after the online course. Results of pre-post instruction analyses between groups and evaluation responses are discussed, as are implications for future instruction.

* This work funded in part by the Adapting the Next Generation Physical Science and Everyday Thinking Curriculum for a Lecture-Laboratory Format grant from the NSF, DUE-1611738.

KF06 (2:10 to 2:20 PM WEDNESDAY) Effectiveness of Next Gen PET online

Poster – Presenting Author: Kris Wedding Crowell, California State University, East Bay

One of the resources available with the Next Gen PET curriculum is a research-based assessment, the Next Gen Physical Science Diagnostic. This assessment has been one commonality over the last two years of teaching through a pandemic. I have taught an online version of NGPET for three semesters, and am finishing my second semester back in person. I have used the same workbooks and activities in both versions of the course. Comparing the pre-post results over the last two years can be used to help answer the question of how much students learn in an online version of the class compared to in-person learning. Preliminary results support the generally accepted hypothesis that in-person, hands-on learning is more effective, however the online NGPET learning gains were better than a typical lecture-style in-person course, which indicates that an active learning approach, even on-line, can benefit students.

KF07 (2:20 to 2:30 PM WEDNESDAY) The Results of Covid Induced Changes to a NextGenPET Omplementation

Poster – Presenting Author: Tamara Snyder, University of Arkansas

The studio version of the Next Generation Physical Science and Everyday Thinking (NextGen PET) curriculum depends on students working together in small groups in the classroom. As the spring 2022 semester started, we were still under some covid protocols and there were fears that a new wave of mass absences were going to start. In this poster I will present some of the changes that I made to my course as a result of these pressures, and I will discuss the results of these changes: how learning gains and "student happiness" were affected.

Session KG: Smart Phone-based Labs

Location: CC: Grand Gallery Overlook G **Sponsor:** AAPT
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** Andrew Gavrin

KG01 (12:40 to 12:50 PM WEDNESDAY) Integrating Smartphones and Making in a Computational Physics Course

Contributed – Presenting Author: Timothy Atherton, Tufts University

Additional Author | Anna Phillips, Tufts University

Additional Author | Ezra Gouvea, Tufts University

Additional Author | Brian Gravel, Tufts University

Computation is intertwined with essentially all aspects of physics research and is invaluable for physicists' careers. Despite its disciplinary importance, integration of computation into physics education remains a challenge. Here we perform design research to create an educational environment that incorporates making, the creation of shared physical and digital artifacts, and acquisition of data with smartphones. The design is intended to promote students' agency, creativity and self-expression alongside doing physics. We present a content analysis of student work from initial implementations of this approach to illustrate the very complex epistemic maneuvers students make as they engaged in computational modeling and some of the creative ways they used smartphones. We conclude with implications of the design for broader instruction.

KG02 (12:50 to 1:00 PM WEDNESDAY) Smartphones in the Introductory Mechanics Lab

Contributed – Presenting Author: Andy Gavrin, IUPUI

Additional Author | Gautam Vemuri, IUPUI

Smartphone based labs are a cornerstone of our efforts to reform the introductory labs in both our calculus-based and algebra-based classes. Students use smartphones to collect data in the lab (Bluetooth paired with sensors) and at home (using the native sensors in the phone). In this talk, we will give a brief overview of the project, then emphasize the at-home labs. These labs have allowed us to substantially reduce crowding in the lab, emphasize data analysis, and give students an opportunity to be more exploratory in their approach to lab. We will highlight examples of our at-home labs and discuss lessons learned during the first year of the project.

KG03 (1:00 to 1:10 PM WEDNESDAY) Simple Acoustics Experiments During the Pandemic

Contributed – Presenting Author: Martin Monteiro, Universidad ORT Uruguay

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

Additional Author | Cecilia Stari, 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 and 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 Fast Fourier 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.

KG04 (1:10 to 1:20 PM WEDNESDAY) Smart Physics: A Path to Innovate Laboratory Physics Experiences*

Contributed – Presenting Author: Jake Postiglione, New York City College of Technology, CUNY

Additional Author | Giovanni Ossola

The SmartPhysics project stems from the collaboration between students and faculty at the University of Padova in Italy and the City University of New York. We explored the benefits of using the sensors which are available on commercial smartphones as laboratory equipment in introductory college/university physics courses. As a sample of our explorations, we discuss two experiments that were developed and tested during the academic year 2021-2022. Both activities make use of the phyphox app. The first one is a revisitation of a classic experiment and aims at measuring the gravitational acceleration using a pendulum and a proximity stopwatch. The second one targets the concept of energy dissipation and measures, by means of acoustic stopwatch, the energy lost by a bouncing ball through a series of inelastic collisions with a hard surface. While these activities can be performed in a traditional laboratory setting, we present at-home adaptations for online courses.

*The work presented stems from an international collaboration between the University of Padova, Italy (1) and the New York City College of Technology of CUNY (2). We list in the following the contributors/authors: Elisa BERNARDINI (1), Marta CARLI (1), Mohamed Yousry ELKHASHAB** (1), Andrea FERROGLIA (2), Miguel FIOLHAIS (2), Lucia GABELLI (1), Henrik JESSEN MUNCH** (1), Darya KRYM (2), Pierpaolo MASTROLIA (1), Giovanni OSSOLA* (2), Ornella PANTANO (1), Jake POSTIGLIONE** (2), Juan Sebastian POVEDA CORREA** (2), Chiara SIRIGNANO (1), Francesca SORAMEL (1).

KG05 (1:20 to 1:30 PM WEDNESDAY) Resonant Acoustic Characterization of Coins: An Inquiry-Based Learning Activity

Contributed – Presenting Author: David Rakestraw, LLNL

This presentation will describe a novel laboratory activity where the acoustic frequencies produced by the resonant vibrational modes of coins are measured using a smartphone's microphone and analyzed in real-time using free mobile applications. The resulting resonant acoustic spectra allow for unique characterization of coins with different physical properties. The activity provides the opportunity to develop student skills in a very simple, yet elegant, experimental design, be exposed to a wide range of fundamental physics phenomena and use powerful visualization tools. In addition to the STEM benefits, students will investigate coins that convey a story of art, society and history creating additional student interest. This presentation will include examples of resonant acoustic spectra for a range of coins and describe a wide range of opportunities for investigation that has been used in introductory high school physics or can be extended to challenge advanced physics majors in universities.

Session LA: Integrating Climate, Energy, Sustainability in the Classroom and Beyond, Introductory Courses

Location: CC: Grand Gallery A **Sponsor:** AAPT
Time: 1:50–2:50 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

LA01 (1:50 to 2:00 PM WEDNESDAY) Place-Based Education: Situating Energy and Climate Change in Students' Communities

Contributed – Presenting Author: Jessica Hernandez, University of Washington Bothell

Additional Author | Rachel Scherr, University of Washington Bothell

Additional Author | Molly German, Gridley Unified

Additional Author | Rey Horowitz , The Packer Collegiate Institute

The field of physics education has struggled to create culturally based, responsive, and relevant curriculum to engage students of color. This may be partly due to the perception that physics is apolitical and acultural, despite many concepts being socio-politically situated in our current society. To the extent that physics maintains an acultural and apolitical stance, physics education cannot be place based, because the notion of place is politically and culturally situated to students' environments. To bridge this gap, we worked with physics teachers in a yearlong professional learning community (PLC) to incorporate place-based education into their science curriculum. Place-based education teaches students to take care of their environments by situating potential actions they can take to support their local communities in addressing climate change impacts. In our two case studies, we describe how physics teachers situated the concepts of energy and climate change in students' local environments.

LA02 (2:00 to 2:10 PM WEDNESDAY) Climate Science for Teachers

Contributed – Presenting Author: Frank Lock, Climate Reality Project

This presentation will take a thermodynamic approach to presenting concepts about climate science. It is appropriate for presentations to teachers and is the basis for preparing presentations to students in grade six through 12. The presenter has numerous presentations appropriate for students in those grades and is willing to share them with teachers who wish to make climate science presentations to students. The climate emergency is a great threat to the future of our culture. It is important that students be made aware of what needs to be done to insure their future.

LA03 (2:10 to 2:20 PM WEDNESDAY) Students' Critical Thinking Skills in Relation to Climate Change

Contributed – Presenting Author: Magdalena Micoloi, TU Dresden

Critical thinking is an important skill for students, particularly in the climate change debate. Students need to be able to distinguish between facts and misinformation. In order to access students' critical thinking skills semi-structured interviews were conducted with eight students aiming to become future physics teachers as well as with five students from Saxonian high schools. The interviews were based on five competences of critical thinking defined by Halpern (verbal reasoning, argument analysis, hypothesis testing, likelihood and uncertainty, problem solving and decision making) as well as content knowledge about climate change (such as greenhouse effect, carbon cycle, etc.). All interviews were recorded, transcribed and analyzed using the qualitative content analysis by Kuckartz. The results from the interviews form the base for the development of the test on critical thinking on climate change, as well as teaching materials to enhance critical thinking skills. The results from the interviews will be presented.

LA04 (2:20 to 2:30 PM WEDNESDAY) Exploration of Students' Attitudes and Self-regulation in Two Instructional Modalities

Contributed – Presenting Author: Bijaya Aryal, University of Minnesota Rochester

We have designed an introductory algebra-based physics course using a two-staged instructional model emphasizing the application of physics learning. As a part of the assessment plan, we ask students to complete metacognitive activity of writing reflective descriptions of their learning processes, learning approaches, and strategies for course-related tasks. When we taught the course in a remote instruction modality, we adjusted without altering the instructional philosophy and key assessment components of the course. Our analysis has identified a trend relating to the quality of the student reflection as one of the predictors of their course performance. In this presentation, I will focus on the relationship between the qualities of students' metacognitive reflection with the student's attitude toward physics learning measured using the CLASS survey. Additionally, I will present a comparative study revealing the impact of remote instructional modality on students' self-regulation, self-awareness, and attitude towards physics learning.

LA05 (2:30 to 2:40 PM WEDNESDAY) Building Critical Thinking Skills in General Education Science Courses

Contributed – Presenting Author: D. Blane Baker, William Jewell College

Courses designed for non-science majors provide many opportunities for developing critical thinking skills. Such skills prepare students to thrive as workers in ever-changing environments and as engaged citizens in society. To develop these skills in classroom settings, teachers must educate students on the importance of these skills and engage them in their practice. This talk provides an overview of how this can be done in general science courses. Particular attention is given to prompts given to students, students' responses, and critiques of their work.

LA06 (2:40 to 2:50 PM WEDNESDAY) Assessing Students' Knowledge and Skills with 3 Dimensional Learning

Contributed – Presenting Author: Paul Bergeron, Michigan State University

Additional Author | James T. Laverty, Kansas State University

Three-Dimensional Learning (3DL) is a framework that provides tools to help highlight what we want our students to be able to do with their knowledge. This framework creates opportunities for students to learn physics in sways authentic to the practice of science by aligning course content along 3 Dimensions: Scientific Practices that encompass what scientists do to explore phenomena, Core Ideas that underpin our discipline's central concepts, and Crosscutting Concepts that provide the lenses for how we view phenomena. Research into 3DL has shown that implementing the framework provides substantial benefits to student learning, but does take effort. In this talk, I will present ways to approach 3DL and how use it to create assessment items. In particular, I will discuss how the3 Dimensional Learning Assessment Protocol can be used to create new 3D physics assessment items.

LA07 (2:50 to 3:00 PM WEDNESDAY) Physics for Humans

Contributed – Presenting Author: Randall Tagg, University of Colorado Denver

First-year physics students studying mechanics and electrodynamics are introduced briefly to real-world applications of specific topics. Contemporary examples of actual innovations by physics students show that early development of a mindset to connect physics to hu-

man needs has powerful impact on individual student lives and on regional economies. A potential course bridging to the major would systematically work through major areas of human needs and aspirations to synthesize how multiple topics in physics are combined to solve specific and urgent problems. Twenty-four major categories span essentials like energy, food, and water, cover breakthroughs in health care, transportation, and manufacturing, and imaginatively find connections to sports, retail, and finance. Open problems can be introduced, inviting students to think of innovative solutions for the future.

Session LB: Introductory Labs/Apparatus

Location: CC: Grand Gallery B **Sponsor:** Committee on Apparatus
Time: 1:50–2:50 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

LB01 (1:50 to 2:00 PM WEDNESDAY) Claims, Evidence and Reasoning in the Introductory Mechanics Lab

Contributed – Presenting Author: Andrew Pawl, University of Wisconsin-Platteville

Introductory mechanics is classified as a general education laboratory science at many colleges and universities. General education outcomes often include the ability to reason from evidence or justify claims with evidence. These skills are also central components of the Next Generation Science Standards for K-12 education. In contrast to this mandate to focus on empirical reasoning, both the teaching and the assessing of the ability to reason from evidence are often implicit rather than explicit parts of the introductory mechanics laboratory curriculum. In this presentation I report the first results of an ongoing attempt to scaffold the learning of reasoning from evidence and to make the assessment of this skill explicit by employing the "Claim, Evidence and Reasoning"[1] framework in a college-level, algebra-based introductory mechanics laboratory.

[1] K.L. McNeill and J. Krajcik, 2011.

LB02 (2:00 to 2:10 PM WEDNESDAY) Physics Labs that Resonate with Pre-med Students

Contributed – Presenting Author: Alexandra Hopps, Brigham Young University

Additional Author | Madeline Shumway, Brigham Young University

Additional Author | Nathan D Powers, Brigham Young University

Additional Author | M. Jeannette Lawler, Brigham Young University

Additional Author | Adam Bennion, Brigham Young University

A primary learning outcome for our introductory physics labs for non-majors is scientific modeling. With over 80% of our students planning to enter the health profession, we have been seeking to create project-based labs with obvious applications to medical fields. We recently designed a lab where students model MRI principles, such as gradient magnetic fields and the relationship between magnetic field strength and magnetic resonance, using electromagnets. In this talk, I will discuss the lab prompts and present experimental data collected in the lab.

LB03 (2:10 to 2:20 PM WEDNESDAY) Innovative Experiments with Inexpensive Lab Kits for Introductory Physics Labs

Contributed – Presenting Author: Kavindya Senanayake, Saginaw Valley State University

Additional Author | Ming-Tie Huang, Saginaw Valley State University

Additional Author | Benjamin Keen, Saginaw Valley State University

Additional Author | Christopher Nakamura, Saginaw Valley State University

Additional Author | Marian P Shih, Saginaw Valley State University

Additional Author |Matthew D. Vannette, Saginaw Valley State University

Covid-19 made physics teachers think creatively about presenting hands-on introductory lab courses. In spring of 2020, the SVSU physics department began developing a lab curriculum with the flexibility to execute mechanics and E&M experiments in remote, in-person, or hybrid modalities. A returnable equipment kit may be picked up by or mailed to the student at the start of the term. The kit consists of a combination of inexpensive, commonly available materials and custom 3-D printed components. Data collection is facilitated by the mobile app Phyphox. The experiments were designed to be simple but produce good results. This project gave us the opportunity to look at our curriculum and pedagogy goals in a new way. An internal grant is funding efforts to integrate the inexpensive kit-based experiments with more traditional lab experiences. Our current work and future goals will be presented.

LB04 (2:20 to 2:30 PM WEDNESDAY) Flux Concept Discovery Lab

Contributed – Presenting Author: Gabriel Spalding, Illinois Wesleyan University

Additional Author | Jacqueline R. Rupprecht, Illinois Wesleyan University

Additional Author | Matthew A. Fritsch, Illinois Wesleyan University

Additional Author | Ethan C. Ruth, Illinois Wesleyan University

Additional Author | Matthew Kubas, Illinois Wesleyan University

We will share our "Flux Concept Discovery Lab," an instructional lab for our first-year students to do in "Physics I," which was developed by our students in "Intermediate Experimental Methods," a course taught at the second-year level. We will describe progress our students have made, using $5 plate magnets and a turntable (which, for remote students, can be made from paper plates), as well as ways this activity can be extended or connected to other intro-lab exercises.

LB05 (2:30 to 02:40 PM WEDNESDAY) How Did They Time That? An Investigation of Fall Time

Contributed –Presenting Author: Eugene Torigoe, Thiel College

During an introductory physics lab on drop times, I asked my students to time intervals less than the average human reaction time. To my surprise almost all the students were able to accurately time these short falls. It led to the possibility that students were not merely reacting to the falling object but were predicting when the ball would hit the ground. I used this surprising observation as an opportunity to explore competing explanatory models. Students came up with fun and interesting experiments to distinguish these two models. In this talk I will discuss the experiments, and what my students found.

LB06 (2:40 to 2:50 PM WEDNESDAY) What Went Wrong in Mass-Spring Conservation of Energy?

Contributed – Presenting Author: Guofen (Heather) Yu, The University of Findlay

Additional Author | Steven Wild, The University of Findlay

We have a General Physics I lab activity for students to investigate conservation of energy in a mass-spring system. A mass is hanging on a spring and oscillates up and down. The speed and height are recorded using a Pasco 850 universal interface and a motion sensor. The kinetic energy, potential energy, and total energy are calculated and graphed. Initially, the mass of spring was not taken into account. The variation of the system's energy with time could be as high as 40% of the maximum energy. After including the mass of the spring and testing for lighter and heavier springs, there was still 5-20% oscillation of a system's total energy. Our measurements and findings are to be reported.

Session LC: PER: Assessment, Grading and Feedback III

Location: CC: Grand Gallery C **Sponsor:** Committee on Research in Physics Education
Time: 1:50–2:50 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

LC01 (1:50 to 2:00 PM WEDNESDAY) Measuring Changes in Student Reasoning: Theoretical Framework and Methodology*

Contributed – Presenting Author: Brianna Santangelo, North Dakota State University

Additional AuthorWEDNE | Mila Kryjevskaia, North Dakota State University

Additional Author | Alexey Leontyev, North Dakota State University

One of the goals of physics instruction is to help students develop and refine their reasoning skills. However, measuring changes in reasoning is challenging since both content understanding, and appropriate reasoning strategies are necessary to arrive at a correct response. An instrument that would allow us to disentangle these factors (to the degree possible) would also allow us to measure changes along these two dimensions. In this study, we are drawing on the Dual-process theories of reasoning (DPToR) to develop an instrument based on the screening-target methodology: screening questions probe student conceptual understanding, and target questions require the application of that understanding in more complex situations. Comparison of performance on screening and target questions makes it possible to infer changes in conceptual understanding and reasoning skills due to instruction. We will show illustrative examples of student performance and discuss the implications for instrument development and implementation.

*This material is based upon work supported by the National Science Foundation under Grant Nos. FAR-0035257, DUE-1431940, DUE-1431541, DUE-1431857, DUE-1432052, DUE-1432765, DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, DUE-1821561.

LC02 (2:00 to 2:10 PM WEDNESDAY) Impact of Response-Shift Bias on Students' Sense of Relevance

Contributed – Presenting Author: Ivy Shaw, University of North Florida

Presenting Author | Brendan McEnroe, University of North Florida

Additional Author | Dr. W. Brian Lane, University of North Florida

Response-shift bias (RSB) describes how instructional interventions induce a downshift in students' self-assessment of their pre-instructional capabilities and interests, such as measured by the Colorado Learning Attitudes about Science Survey (CLASS). This downshift produces a misalignment between the students' perception of their learning experience and pre-to-post self-assessment shifts, possibly explaining why positive CLASS shifts are difficult to obtain. To further explore this downshift, we added a reflective question to four items on the CLASS asking students to explain how they determined their responses. We examine correlations between themes in students' reflections, finding that the students made more connections with their conceptual knowledge at the end of the semester than at the beginning. This change highlights the role of RSB in their survey outcomes. These trends offer insight into additional dimensions of the student learning experience and could help physics educators design more engaging courses.

LC03 (2:10 to 2:20 PM WEDNESDAY) Analyzing Students' Sensemaking with Algebraic Inequalities

Contributed – Presenting Author: AMOGH SIRNOORKAR, Kansas State University

Additional Author | James T Laverty, Kansas State University

'Doing physics' entails extensive use of mathematical expressions to contain and convey contextual information. Consequently, students' sensemaking on mathematical formalisms has attracted considerable attention in physics education research (PER). In the current work, we explore how introductory students construct meaning using algebraic inequalities while sensemaking on a physics problem. We qualitatively analyze a case study of a student (pseudonym: Matthew) through the frameworks of Sensemaking Epistemic Game and Symbolic Forms. The case study highlights Matthew's verbal and written references to inequalities 'driving' explanation generation during sensemaking. A preliminary analysis of Matthew and other students' references to inequalities reveals a cluster of `comparing' symbolic forms conveying the idea of a quantitative comparison between physical quantities. Observations made in this study shed insights on how students construct and extract meaning through algebraic inequalities.

LC04 (2:20 to 2:30 PM WEDNESDAY) | Contributed | Interpreting Item Response Theory Results Using a Thermodynamic Analogy

Contributed – Presenting Author: Trevor Smith, Rowan University

Additional Author | Nasrine Bendjilali, Rowan University

Several recent studies have employed item response theory (IRT) to rank incorrect responses to commonly used research-based multiple-choice assessments. These studies use Bock's nominal response model (NRM) for applying IRT to categorical data, but the response rankings only utilize half of the parameters estimated by the model. We present a mathematical argument for why this practice of using half of the NRM parameters when ranking responses is appropriate based on the primary question of multiple-choice tests: How can we use students' responses to test items to estimate their overall knowledge? We provide additional motivation for this practice by recognizing the similarities between Bock's NRM and the probability function of the canonical ensemble with degenerate energy states. As physicists often do, we exploit these mathematical similarities to gain new insights into the meaning of the IRT parameters and a richer understanding of the relationship between these parameters and student knowledge.

LC05 (2:30 to 2:40 PM WEDNESDAY) Development of a Likert-style instrument to assess LA's PCK-Q*

Contributed – Presenting Author: Beth Thacker, Texas Tech University

Additional Author | Stephanie Hart, Texas Tech University

Additional Author | Kyle Wipfli, Texas Tech University

Additional Author | Jianlan Wang, Texas Tech University

As part of a project to develop a written instrument for assessing learning assistants' (LAs') pedagogical content knowledge (PCK) in the context of questioning (PCK-Q), we are experimenting with questions in a Likert-style format. Previously, we have developed and validated questions in free-response format. We are now using those questions as the basis for Likert-style questions. Likert-style questions are different because they require the LAs' to evaluate possible LA responses to students in classroom scenarios. They are also beneficial because scoring can be automated. The instrument will examine a LA's ability to identify appropriate responses that provide evidence of the application of PCK-Q in the classroom. We will discuss problem development, present sample problems, and outline ongoing plans regarding validation, reliability testing, and dissemination efforts.

*Funded by NSF IUSE grant 1838339

LC06 (2:40 to 2:50 PM WEDNESDAY) Affordances of Articulating Assessment Objectives

Contributed – Presenting Author: Michael Vignal, University of Colorado Boulder

Additional Author | Katherine Rainey, University of Colorado Boulder

Additional Author | Marcos D. Caballero, Michigan State University

Additional Author | Bethany Wilcox, University of Colorado Boulder

Additional Author | Heather Lewandowski, University of Colorado Boulder

Concise, specific, and measurable statements of desired student learning, often called learning objectives, can aid instructors during curricular development. Similar statements, which we call assessment objectives, can aid researchers in developing and validating research-based assessments. In this talk, we discuss the benefits of articulating assessment objectives during the development of two assessments, one for upper-division thermodynamics and one for lower-division physics labs. Specifically, assessment objectives helped us identify concepts and practices that are important to instructors, aided in the development of targeted assessment items, provided an additional means for establishing face and construct validity, and can serve as a way for instructors and researchers to determine if these assessments are appropriate for use in their courses and research studies in the future.

LC07 (2:50 to 3:00 PM WEDNESDAY) A Comparative Study of RTOP and Toshiba Cup Scoring Table

Contributed – Presenting Author: Dazhen Tong, East China Normal University

Additional Author | Zengze Liu, East China Normal University

Additional Author | Sudong Pan, East China Normal University

The new round of basic education curriculum reform in China recently will inevitably bring about the reform of classroom teaching. To find a method of testing the reformed classroom teaching effect so that it follows the new curriculum reform is a problem that needs to be solved urgently. On the basis of examining the evaluation concept and application of the "Reformed Classroom Teaching Observation Protocol (RTOP)" originated in the United States, we test the appropriateness of RTOP in China's physics classroom teaching evaluation environment from both qualitative and quantitative perspectives in a class on Newton's third law, with good results. By comparing the advantages and disadvantages of RTOP and China's "Toshiba Cup Scoring Table", it is found that RTOP can provide guidance for the transformation of classroom teaching evaluation concepts and the development of evaluation tools in the context of China's new curriculum reform.

Session LD: Short Courses and Other Innovations

Location: CC: Grand Gallery F **Sponsor:** TBA
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

LD01 (1:50 to 2:00 PM WEDNESDAY) A Chapter per Day: An Account of 7.5 Week Sessions

Contributed – Presenting Author: Tyler Scott, Grace College

At Grace College, most courses, including all in The Department of Science and Mathematics, are offered in 7.5 week sessions. These include Physical Science Survey, College Physics I & II, and University Physics I & II courses. In this talk, I discuss my process for designing the courses for an accelerated rate, my experiences implementing them, and some assessments of student outcomes. While it was easier than I expected to compact these courses to a chapter a day, outcomes, especially for athletes and underprepared students, are not always positive.

LD02 (2:00 to 2:10 PM WEDNESDAY) "Short Course" Does Not Translate to "Short Time"

Contributed – Presenting Author: Beverly Trina Cannon, Dallas College Richfield Campus

Having taught Short Courses for Physics, both on-line and face to face, I have determined that time is the enemy. While all faculty members are encouraged to know the student, make connections across the curriculum, be available for the students that need the extra interactions, provide some direction and links between the course and the real world, potential career options as well as updating course materials with current accomplishments of research projects, a well-planned and orchestrated course can be a real pipe-dream. "Short" can be defined as 4, 6 or 8 weeks. The "time" for participation and completion of the course may not fall within the calendar structure. Students directed toward "short" courses may be in whirlwinds of their own lives. Are we really promoting good physics practices and reflecting the direction that Physics Education Research has revealed?

LD03 (2:10 to 2:20 PM WEDNESDAY) Gee-Whiz! Encouraging Undergraduate Students to Move towards Experimental Physics

Contributed – Presenting Author: Lalitasri Nandivada, University of Waterloo

Additional Author | Karen Cummings, University of Waterloo

Additional Author | Donna Strickland, University of Waterloo

Additional Author | Meg Ward, University of Waterloo

In this talk, we will present an overview of an undergraduate laboratory experiment we are developing which focuses on techniques in ultrafast laser physics. Specifically, we are developing an experiment on frequency-doubling making use of an ultra-fast laser. This experiment is noteworthy because it is part of a new "Gee-Whiz!" set of experiments we are developing to encourage students to consider pursuing experimental physics in our highly theoretical department. The experiment will also embody a modeling-based approach like those developed by Dr. Natasha Holmes and Dr. Carl Wieman at the University of British Columbia and Cornell University. We have also transitioned our first-year labs to this approach and report on our related findings elsewhere. We believe that using this approach to develop the new labs will reach our goal in encouraging student interest in experimental physics.

Session LE: Quantum Education in the High School Classroom

Location: CC: Grand Gallery Overlook A/B **Sponsor:** Committee on Science Education for the Public
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** Chandralekha Singh

LE01 (1:50 to 2:00 PM) Well Developed Curriculum and Pedagogy of Quantum Mechanics for Adolescents

Contributed – Presenting Author: Solmaz Khodaeifaal, Simon Fraser University

With an exploratory study of science education for middle or junior high schools, this paper explains why a physics teacher endeavours to develop an updated and adapted curriculum and pedagogy to support and empower adolescents by initiating their learning in physics and moving on to quantum mechanics at their early ages (Grades 8–10) in a science program during our complex contemporary times. Furthermore, the study discusses how the teacher develops such a curriculum and utilize technological pedagogical tools to engage and encourage young students, particularly girls, to learn mathematical sciences connected to their everyday lives and lived experiences, not as a school subject but as required scientific knowledge and skills for 21st-century achievements. Such initiation can create opportunities to learn physics over a longer period of time, broaden girls' participation, increase their self-confidence, and practise essential STEM skills such as critical thinking, problem solving, collaboration, innovation, and so forth.

LE02 (2:00 to 2:10 PM) Integrating Quantum in the IB High School Physics Classroom

Contributed –Presenting Author: W. Brian Lane, Osprey Physics Teaching Initiative (OPT-In), Department of Physics, University of North Florida

Presenting Author | Sebastian Cardozo, OPT-In, Duval County Public Schools

Additional Author | Forouzan Faridian, OPT-In, Santa Monica College

Additional Author | Terrie M. Galanti, OPT-In, Department of Teaching, Learning and Curriculum, University of North Florida

Additional Author | Julia Whitley, OPT-In, University of North Florida

Our students' careers will increasingly involve quantum physics as industrial quantum applications grow. However, the learning of quantum concepts largely remains separated from the high school physics experience where students first form expectations of how they might use physics throughout their lives. Two primary barriers to integrating quantum into the high school context are conceptual challenges and mathematical formalism. We argue these barriers can be lowered by adopting a computationally integrated spins-first approach, which we implemented in a supplemental quantum unit. We led a cohort of high school physics teachers through this unit in self-paced professional development over two semesters. We then collaborated with this cohort to adapt the modules to improve accessibility for their students. We present the structure of our professional development activities, report on the successes and challenges thus far, and share the reflections of a teacher who is implementing these modules in his IB physics classroom.

LE03 (2:10 to 2:20 PM) Quantum Physics in Secondary Schools – An Analysis of PER

Contributed – Presenting Author: Zac Patterson, The Ohio State University

Additional Author | Lin Ding, The Ohio State University

Exposure to contemporary physics topics in secondary schools has increased substantially in recent years yet is still an understudied area with a limited body of research on this topic. We set out to examine the existing body of physics education research (PER) associated with the teaching and learning of quantum physics at the secondary level. First, we quantitatively examine research publications on this topic, looking at characteristics such as yearly output, citation index, author nationality, and publishing venue. Then, an assessment of publication trends in teaching in learning are explored. Lastly, we identify gaps in the research and propose opportunities for further inquiry. The academic search engines SCOPUS and Web of Science were used to collect publications for analysis.

Session LF: Strategies for Teacher Recruitment

Location: CC: Grand Gallery E **Sponsor:** AAPT
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

LF01 (1:50 to 2:00 PM) The Five "W's" of Leading Virtual Workshops

Contributed – Presenting Author: Jon Anderson, University of Minnesota

This will be a presentation about leading virtual professional development workshops for physics teachers from the perspective of an experienced modeling workshop leader. The who, what, when, where, and why (and how as a bonus question!) of leading virtual workshops will be explored. In the summers of 2020 and 2021, I led or co-led a total of 11 weeks of virtual professional development workshops for high school physics teachers. In this session, I will discuss the challenges, lessons learned, and successes of these virtual workshops as well as suggestions for future virtual workshops.

LF02 (2:00 to 2:10 PM) What Promotes Sustainability of PhysTEC-funded Physics Teacher Education Programs?*

Contributed – Presenting Author: Stephanie Chasteen, Chasteen Educational Consulting

Additional Author | Alexandra Lau, American Physical Society

Additional Author | Michael Wittmann, American Physical Society

This talk reports on an intensive sustainability study of 16 formerly funded PhysTEC institutions.* Institutions often sustained outcomes including a quality physics teacher education (PTE) program, teacher graduation rates, leadership, and structures, especially LA programs. On average, teacher graduation rates sustainably increased by 1 teacher/year (2 teachers/year for the N=11 with gains). The most highly sustained sites were hallmarked by strong supportive institutional culture and structures for PTE: Motivated people were not enough. The PhysTEC grant enabled sites to establish proof of concept that PTE was viable, leading to further institutional support in a positive feedback loop. I found that these results were well-explained by a model of instructional change by Lau et al.

** The full report is at https://phystec.org/publications-reports.* We acknowledge funding from NSF-0808790, NSF-1707990.

** A. Lau, et al. "Active learning in intro courses: A study of 18 high active learning use departments", AAPT Summer Meeting, 2021

LF03 (2:10 to 2:20 PM WEDNESDAY) Noyce at a PUI: Outcomes and Sustainability*

Contributed – Presenting Author: AJ Richards, The College of New Jersey

Additional Author | Nathan Magee, The College of New Jersey

Additional Author | Lauren Madden, The College of New Jersey

Additional Author | Marissa Bellino, The College of New Jersey

Additional Author | Melissa Chessler, The College of New Jersey

The College of New Jersey is sunsetting a grant from the Robert Noyce Teacher Scholarship Program. As a result of the grant, we were able to greatly strengthen our physics teacher preparation program, roughly doubling our annual average of new physics teacher certifications (being honored in PhysTEC's prestigious "5+ Club" twice in five years) and developing innovative programming. In this presentation we will outline the major outcomes of the grant, discuss the setting of the grant's programming at a mid-size state PUI, and report how we hope to sustain the program's benefits after the grant's expiration this year.

*This project is supported by NSF Award #1557357.

Session LG: Training Learning Assistants and Graduate Students to be Effective Lab Assistants II

Location: CC: Grand Gallery Overlook C/D **Sponsor:** AAPT
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

LG01 (1:50 to 2:00 PM WEDNESDAY) A National Survey of Physics Graduate TA Preparation

Contributed – Presenting Author: Gregory Carroll, Georgia Institute of Technology

Additional Author | Emily Alicea-Munoz, Georgia Institute of Technology

The preparation of graduate teaching assistants (GTAs) to learn classroom dynamics and physics pedagogy is a vital step in the development of the next generation of academic leaders and communicative scientists. However, there is no current research published on the overall landscape of GTA preparation around the country nor the various manners of evaluating the effectiveness of said preparation. We conducted a pilot survey of 15 randomly selected physics PhD-granting institutions in the United States to identify some of the methods used for GTA preparation and their assessments. In this talk we present the development of the pilot survey and preliminary results. This pilot investigation sets up the framework for a future expanded survey of all physics PhD granting institutions, which will allow us to fill the gap in the literature and explore how GTAs are prepared across the country.

LG02 (2:00 to 2:10 PM WEDNESDAY) Post-Semester Feedback Meetings to Encourage Teaching Growth

Contributed – Presenting Author: J. Reid Mumford, Johns Hopkins University

It is widely accepted that weekly training meetings are essential for TA and LA preparation in laboratory courses. The weekly meetings typically focus on the immediate challenges and nuance of the specific upcoming laboratory activity with little time for larger pedagogical discussions. In this talk, I will describe one-on-one meetings, conducted at the end of the semester, to provide summative feedback to Teaching Assistants on their teaching. These meetings provide an opportunity to review student surveys and course evaluations to celebrate success, identify areas for potential growth, and collaboratively develop strategies for how to improve their future teaching.

LG03 (2:10 to 2:20 PM WEDNESDAY) TA Training by TAs: Attitudes in the Undergraduate Lab Environment

Contributed – Presenting Author: Stephen Lane

Physics teaching assistants (TAs) often play a large part in student education through their role in the undergraduate laboratory setting. However, training and mentoring for TAs is often minimal, particularly in regards to pedagogy and effective learning strategies. Moreover, TA duties may sometimes be framed as an inconvenient side effect of graduate school. Here we discuss the support and motivation behind a department-specific training session developed by TAs for TAs. They are framed as physics instructors with a crucial role to play, and we attempt to improve their attitudes toward the students in undergraduate laboratories, in an effort to foster the confidence needed for interactive engagement. Pedagogy of constructivism, engagement, and assessment is introduced, motivated by helping TAs perform their duties confidently and effectively. Finally, we address community-building efforts within the TA population.

Session LH: PER: Student and Instructor Support & Professional Development, Program and Institutional Change IV

Location: CC: Grand Gallery Overlook G **Sponsor:** Committee on Research in Physics Education
Time: 12:40–1:40 p.m. **Date:** Wednesday, July 13 **Presider:** TBA

The Illinois Physics and Secondary Schools Partnership Program

Contributed – Presenting Author: Tim Stelzer, University of Illinois

Additional Author | Eric Kuo, University of Illinois

Additional Author | Morten Lundsgaard, University of Illinois

Additional Author | Maggie Mahmood, University of Illinois

Additional Author | Hamideh Talafian, University of Illinois

The Illinois Physics and Secondary Schools (IPaSS) partnership program connects in-service high school physics teachers across the state with the University of Illinois at Urbana-Champaign. IPaSS aims to address disparities in physics instruction by equipping teachers with university physics curricula and equipment adapted to fit the context of their high school classrooms. The program is now in its second year and serves 14 physics teachers from across the state. By the end of year four of the program, it will include 40 teachers. Each year, teachers attend 70 hours of in-person and online professional development in the summer, followed by one hour of online bi-weekly PD throughout the school year. Each teacher has free access to University of Illinois equipment and materials and gets two school visits per semester. In this presentation, we describe the design-based structure of the program and how it responds to physics teachers' needs.

*This work was supported by NSF DRL 20-10188

KC06 (1:30 to 1:40 PM) Teachers' Perceptions of a Design-based Research Practice Partnership Program

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

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

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

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

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

IPaSS is a partnership program between the University of Illinois and secondary school physics teachers across the state. The program is designed to be responsive to teachers' instructional needs by equipping them with research-based, vetted, university-level instructional materials. In this presentation, we share the results of interviewing 14 physics teachers who joined the program over the past two years with varying levels of experience. The teachers have been involved in a design-based professional development program both in-person and online. The analysis of the video data revealed three main findings: 1) the design-based structure of the PDs provided conceptual, social, and emotional support, 2) access to university resources supported immediate implementation into their classroom practices, and 3) the program and colleagues' perpetual support throughout the year distinguished IPaSS from their experience in other professional development programs.

EG06 (8:50 to 9:00 AM) Physics Teachers Learning in Professional Development Settings: A Case Study*

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

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

Additional Author | Hamideh Talafian, 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

Group content reasoning tasks are necessary within physics teacher professional development (PD) to support teachers' Pedagogical Content Knowledge (PCK); however, such activities involve social risks to the participants, such as revealing to others one's gaps in understanding. This descriptive case study examines a veteran and preservice physics teacher pair's conversational moves while discussing responses to a physics problem in a PD meeting. In the interaction, emerging social risks experienced by the preservice teacher are mitigated by comfort-building moves, allowing her to engage more deeply in the discipline-based conversation. Comfort-building moves at first allow both teachers to get "unstuck" from tense or awkward moments, and later lead them to take greater risks. This case highlights the need for more focus on the affective dimensions of practice-centered activities between teachers in PD contexts, especially as they bring together participants with a variety of skillsets in a Community of Practice.

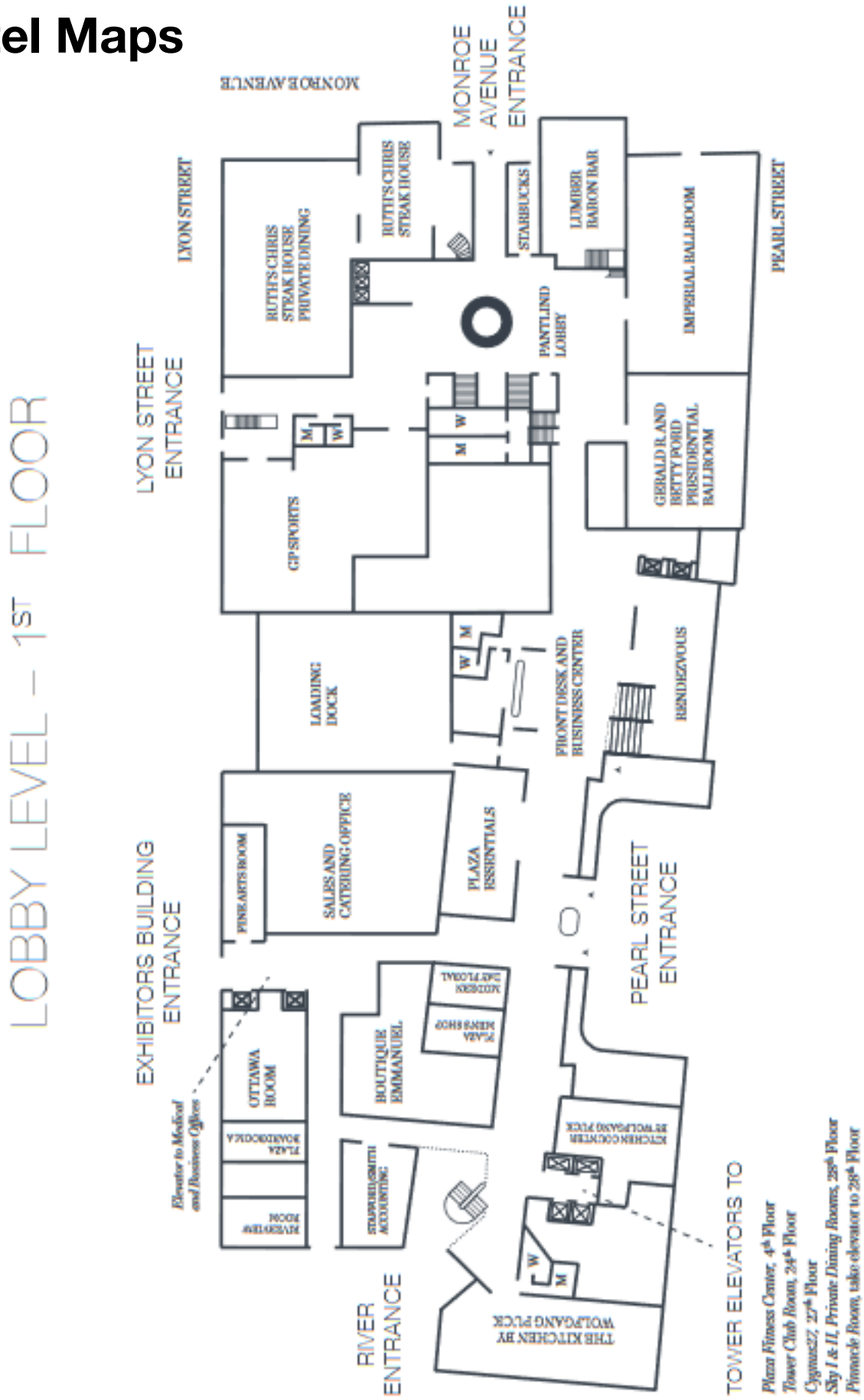
*This work was supported by NSF DRL 20-10188.

Convention Center Map

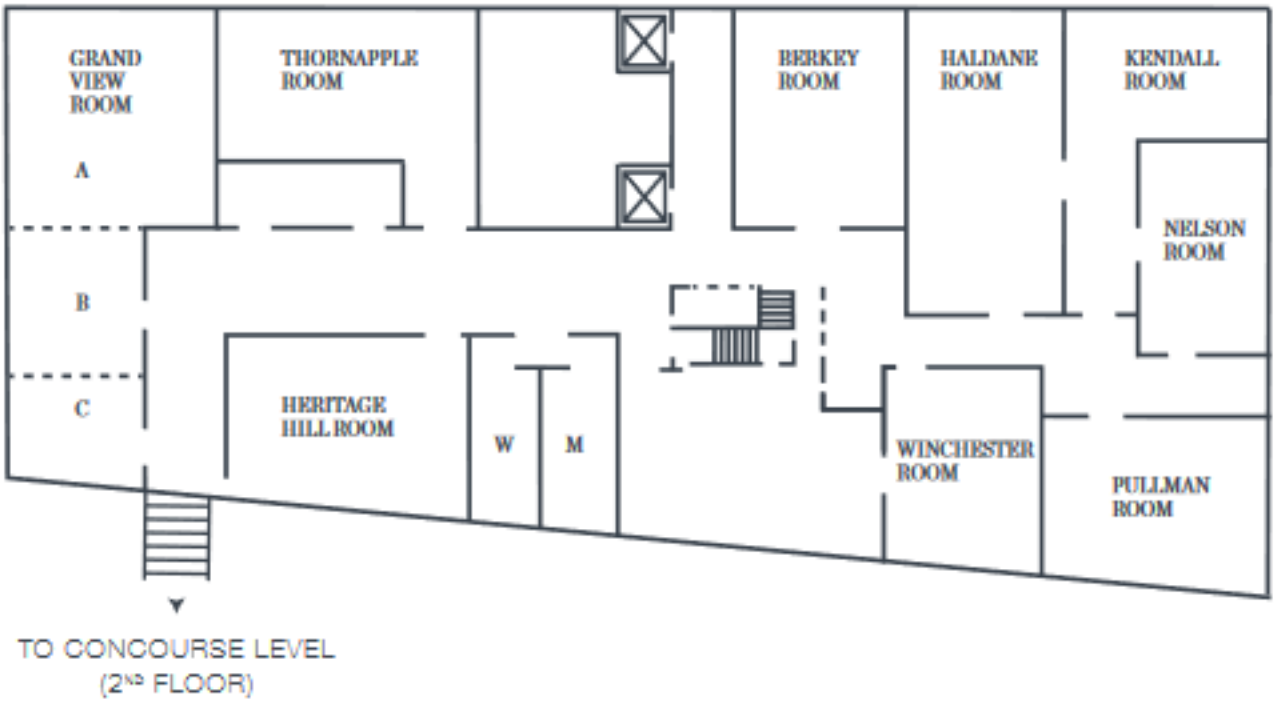
DEVOS PLACE CONVENTION CENTER STREET LEVEL

DEVOS PLACE CONVENTION CENTER OVERLOOK & SKYWAY LEVEL

Hotel Maps


LOBBY LEVEL – 1ST FLOOR
MONROE AVENUE
MONROE AVENUE ENTRANCE
LYON STREET
LYON STREET ENTRANCE
RUTH'S CHRIS STEAK HOUSE PRIVATE DINING
RUTH'S CHRIS STEAK HOUSE
STARBUCKS
LUMBER BARON BAR
PANTLIND LOBBY
IMPERIAL BALLROOM
PEARL STREET
GP SPORTS
GERALD R. AND BETTY FORD PRESIDENTIAL BALLROOM
LOADING DOCK
FRONT DESK AND BUSINESS CENTER
RENDEZVOUS
FINE ARTS ROOM
SALES AND CATERING OFFICE
PLAZA ESSENTIALS
EXHIBITORS BUILDING ENTRANCE
PEARL STREET ENTRANCE
Elevator to Medical and Business Offices
OTTAWA ROOM
PLAZA BOARDROOM A
RIVERVIEW ROOM
BOUTIQUE EMMANUEL
PLAZA NEWS & SHOP
MODERN JAZZ FLORAL
STAPPERFENSMITH ACCOUNTING
KITCHEN COURTESY RESTAURANT WOLFGANG PUCK
THE KITCHEN BY WOLFGANG PUCK
RIVER ENTRANCE
TOWER ELEVATORS TO
Plaza Fitness Center, 4th Floor
Tower Club Room, 24th Floor
Cygnus22, 22nd Floor
Sky I & II, Private Dining Rooms, 28th Floor
Pinnacle Room, take elevator to 28th Floor

CONFERENCE LEVEL – 3RD FLOOR



CONCOURSE LEVEL – 2ND FLOOR