Abstract Book

2021 AAPT Virtual
Summer Meeting

AAPT
PHYSICS EDUCATION

AAPT 2021 Virtual Summer Meeting

July 31–August 4, 2021

AAPT 2021 VIRTUAL SUMMER MEETING
July 31–August 4
PHYSICS EDUCATION®

American Association of Physics Teachers®

One Physics Ellipse
College Park, MD 2040
www.aapt.org
301-209-3311

AAPT PHYSICS EDUCATION® 2021 VIRTUAL SUMMER MEETING July 31–August 4

Thank You to Our Meeting Sponsors

PASCO scientific

ThorLabs

VRLab Academy

Vernier Software & Technology

Thank You to Our Meeting Sponsors

PASCO scientific

ThorLabs

VRLab Academy

Vernier Software & Technology

Thank You to AAPT's Sustaining Members

The American Association of Physics Teachers is extremely grateful to the following companies who have generously supported AAPT over the years:

American Institute of Physics

Arbor Scientific

Expert TA

Klinger Educational Product Corporation

Morgan and Claypool Publishers

PASCO scientific

Rice University

Spectrum Techniques LLC

Tel-Atomic Inc.

Vernier Software and Technology

Special Thanks

AAPT wishes to thank the following persons for their dedication and selfless contributions to the 2021 Summer Virtual Meeting:

Paper sorters:

Nina Daye Morley
Duane Merrell
Emma Smith
Karen Jo Matsler
Jan Mader
Jon Anderson
Alice Churukian

AAPT Board of Directors

Jan Landis Mader, President
Great Falls High School
Great Falls, MT

Toni Sauncy, President-Elect
Texas Lutheran University
Seguin, TX

Duane B. Merrell, Vice President
Brigham Young University
Provo, Utah

D. Blane Baker, Secretary
William Jewell College
Liberty, MO

Thomas L. O'Kuma, Treasurer
Lee College
Baytown, TX

Chandralekha Singh, Past President
University of Pittsburgh
Pittsburgh, PA

Tommi Holsenbeck
Chair of Section Representatives
Hardaway, AL

Samuel M. Sampere
Vice Chair of Section Reps.
Syracuse University
Syracuse, NY

Krista E. Wood
University of Cincinnati Blue Ash College
Cincinnati, OH

Gabriel C. Spalding
Illinois Wesleyan University
Bloomington, IL

Martha Lietz
Niles West High School
Skokie, IL

M. Elizabeth Parks (ex officio)
Editor, Amer. Journal of Physics

Gary D. White (ex officio)
Editor, The Physics Teacher

Beth A. Cunningham (ex officio)
AAPT Executive Officer

Robert Hilborn (ex officio)
AAPT Assistant Executive Officer

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 **#aaptsm20**. We will also be posting any changes to the schedule, cancellations, and other announcements during the meeting via both Twitter and Facebook. We look forward to connecting with you!

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

Helen Czerski

An Ocean of Physics

Saturday, July 31
11 a.m.–12 p.m.

2021 Klopsteg Memorial Lecture Award: Helen Czerski

Helen Czerski, University College London, London, England, is the 2021 recipient of the Klopsteg Memorial Lecture Award. This award recognizes educators who have made notable and creative contributions to the teaching of physics.

Regarding her selection to receive the 2021 Klopsteg Award Czerski said, "I'm very grateful to the AAPT for recognizing my work in this way. It's always been a mystery to me that physics at school has sometimes had such a bad reputation when it's all about playing with and understanding the world around us. What could be more fun? Everyone who looks closely at their daily lives will see all sorts of fascinating mechanisms, and it's always been a joy to help change the way people see their world."

Czerski is a physicist, first and foremost, but she's acquired a few other labels along the way: oceanographer, presenter, author, and bubble enthusiast. She grew up near Manchester, in northwest England, and spent her childhood playing by the canals and along the old railway routes of the early Industrial Revolution. She studied Natural Sciences (Physics) at Churchill College, Cambridge, finishing with a first class degree. A year later, she returned to Cambridge to study for a PhD in experimental explosives physics, motivated by the opportunity to use high-speed photography to explore the physical world further.

After her PhD, she looked for a pathway that would allow her to continue to build that sort of experiment, but with an application in the natural world. That's when she found out about bubbles and oceans. The Scripps Institution of Oceanography in San Diego was her door into that world, followed by a postdoc at the Graduate School of Oceanography in Rhode Island. She returned to the UK to start her own research program on the physics of oceanic bubbles, first at the University of Southampton and then at her current academic home, University College London.

Czerski gets particularly excited about the physics of the everyday world and the oceans. The oceans are the heart of the Earth's engine, the system of atmosphere, rocks, ice, life and ocean that makes up our planetary life support system. Beyond the purely scientific, she is fascinated by the relationship between human civilizations and the oceans, and how these vast expanses of blue have shaped and influenced the structure of human society.

Upon her return to the UK from Rhode Island, she became a regular science presenter for BBC, in addition to her academic work. Since 2017, her column "Everyday Physics" has been a regular feature in the *Wall Street Journal*. Her book, *Storm in a Teacup: The Physics of Everyday Life,* published by W. W. Norton Company, received rave reviews from the *New York Times*, *Wall Street Journal*, *The Guardian*, and others.

ABSTRACT: When the Apollo astronauts travelled to the Moon, the most memorable photograph they took was of the "Blue Marble": the view of Earth from space. It was undeniable recognition that the blue – the ocean - is the defining feature of our planet. When you look at the physics of Earth, the ocean engine also dominates the story. This talk will be about the physics of the ocean, and the perspective on our planet that we get from exploring it. Zooming in from the very large, we'll get to the very small: the breaking waves and bubbles that are found at the ocean surface. These bubbles help the ocean breathe, and my research is focused on understanding how they form, and how they help that breathing process. But before you can study them, you need to work out how to measure them, so we'll also cover the ways to use sound and light to detect bubbles that are too small to see, or too fleeting to catch. The ocean is full of adventures, and we're really only at the start.

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

Brad Talbert

Physics Is the Portal

Sunday, August 1
11–11:30 a.m.

Paul W. Zitzewitz Award for Excellence in K-12 Physics Teaching – Brad Talbert

The 2021 Paul Zitzewitz Excellence in K-12 Physics Teaching Award winner is Bradford N. Talbert, a physics teacher at Lone Peak High School, Highland, Utah. 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 Talbert said, "I'm very honored to receive this award. To say it comes as a surprise would be an understatement. Thank you."

Educated at Brigham Young University, Provo Utah, Talbert earned his Bachelor of Science in Mechanical Engineering and his Master of Science in Instructional Psychology and Technology. He earned a second Bachelor of Science, and Teacher Certification with Math Level IV and Physics endorsements from Southern Utah University. He received advanced training in Modeling Instruction for High School Physics at Arizona State University.

His career as a teacher began at Southern Utah University where he worked as a Teaching Assistant for College Algebra. In 1997 he began working as an author and instructor of high school physics offered through BYU's Independent Study. His role as a high school physics teacher began at Pleasant Grove High School in 1994. After teaching physics and AP Physics for 15 years, Talbert worked at the state office of education for five years as the state science assessment specialist. During this time he was directly involved with the state end of level science testing. He traveled throughout the state leading trainings and workshops about effective strategies for assessing science content and practices. Near the end of his tenure at the state, Lone Peak High School had an opening for a Physics teacher, and he took the job. He currently teaches Physics, AP Physics 1, and Concurrent Enrollment Physics 1010 in partnership with Utah Valley University.

ABSTRACT: Early physics instruction (9th or 10th grade) opens doors to higher achievement in chemistry, math, advanced biology, and engineering. As students learn to organize complex information to find solutions to assigned problems and engineering tasks, they improve abstract reasoning skills and gain increased self-confidence. A first experience with physics ought to include challenging mathematical structure but also provide many concrete hands-on learning experiences.

Talbert's success as a teacher has been recognized with the 2004 Horace-Mann Crystal Apple Award for teaching excellence, the 2005 Presidential Award for Excellence in Mathematics and Science Teaching, and the 2009 USTA Outstanding Physics Teacher award.

He has a classroom environment that integrates both technology and project-based learning to not only teach base level concepts but to create a rich and immersive culture for students to be passionate about physics. He has worked within a collaborative environment as a mentor for many years using his experience and expertise to reach beyond his classroom and improve our entire Physics team. Students respect Brad as an approachable and caring teacher and feel a part of a community not just a classroom.

In addition to his teaching assignments Talbert is constantly seeking professional development for himself as a lifelong learner with a growth mindset. He is involved yearly with professional development with a focus towards improvement in student learning. He also looks to provide opportunities for students to immerse themselves in the sciences outside of the classroom. He is constantly looking for meaningful ways to connect students to a future in science.

In nominating him for this honor, his principal at Lone Peak High School noted, "Brad also brings a much needed attitude of optimism and joyfulness to his classroom. He takes time to know when his students may be struggling because of the extreme circumstances that far too often exist in their young lives and provides a safe and hopeful environment during his class. He focuses on solutions and not problems and proactively seeks out those that need help and works with them to solve tough problems. He is often working with people to build their capacity, as a great educator always does."

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

David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching – Anne Cox

Anne Cox

Mission Possible

Sunday, August 1
11:30 a.m.–12 p.m.

Anne J. Cox will receive the 2021 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 her selection for this award, Cox said, "I am humbled and honored to receive this award. An award from AAPT is particularly meaningful to me since AAPT has been the means by which I have learned so much about teaching and, more importantly, it has served as a professional home: a community that understands the joys and frustrations of the physics classroom."

Cox is Professor of Physics, Eckerd College, St. Petersburg, FL. She graduated magna cum laude with her BS in Physics at Rhodes College, where she was the only female physics major, and earned her PhD in Physics at the University of Virginia.

She began teaching at Eckerd College in 1995 and has been a dedicated teacher and researcher at the Physics Department, with her appointment as Professor in Physics in 2006. Her outstanding teaching, in physics and across disciplines, was recognized in 2004 when Anne received Eckerd's Robert A. Staub Distinguished Teacher of the Year Award. She has also been a research mentor to over 25 Eckerd students in experimental work: from atomic cluster studies to developing experiments for advanced labs. Cox's current research interests are curriculum development and pedagogical strategies to enhance student learning using technology. She is a contributing author of Physlet Physics: Interactive Illustrations, Explorations, and Problems for Introductory Physics and co-author of Physlet Quantum Physics, both now available on AAPT ComPADRE. In addition, she is the author or co-author of over a dozen papers on the pedagogical use of technology, with papers appearing in The Physics Teacher and Physics Education.

ABSTRACT: When you know your mission, you know what you do better than, different than, other than… for you alone do." (attributed to Robert Hutchins, President of the University of Chicago, 1929- 45) What is it that we, physics teachers, do that is unique—what is our mission and why have we chosen to accept it? I will reflect on what I have learned about physics teaching from many of you as I celebrate our joint mission, share pedagogical strategies, and highlight challenges ahead. This talk will be grounded in the tools of our trade: simulations, laboratories, video analysis, and makerspaces. But it will also acknowledge the human side of physics and the ways in which we connect with each other and our students, particularly through mentoring and JEDI-B work (Justice, Equity, Diversity, Inclusion and Belonging). And yes, there may be a Star Wars reference or two along the way. "Access to a dark night sky—to see and be inspired by the universe as it really is—should be a human right, not a luxury for the chosen few." (Chanda Prescod-Weinstein, *The Disordered Cosmos*, p. 165)

A very active member in the Florida Section of the AAPT, her service has included the leadership positions of President and Section Representative and twice she has hosted a Florida Section meeting. For this work, the FL-AAPT Section recognized Cox with their Distinguished Service Award.

She has also been an advocate for women in physics her whole career, starting as an undergraduate at Rhodes College where she was an advocate for herself, as the only physics major in her year as she recounts in the AAPT video, HERStories. She later participated the NSF ADVANCE sponsored, "Collaborative Research for Horizontal Mentoring Alliances," which was a peer mentoring alliance of five female full professors in physics at liberal arts institutions. This peer mentoring experience led to Anne being a Co-PI on the NSF ADVANCE grant, "Mutual Mentoring to Reduce Isolation in Physics," an AAPT project to develop mentoring networks of isolated women physics faculty.

Cox has been a fixture at AAPT meetings for over 20 years. She has served several times as a member and as chair of Committee on Women in Physics and the Committee on Educational Technology. In those capacities she has organized sessions and given numerous presentations and workshops. In 2008, she received a Distinguished Service Citation and is an AAPT Fellow.

Established as the Excellence in Undergraduate Teaching Award in 1993; it was renamed and substantially endowed in 2010 by John Wiley & Sons. Named for David Halliday and Robert Resnick, authors of a very successful college-level textbook in introductory physics, the award recognizes outstanding achievement in teaching undergraduate physics.

2021 Oersted Medal Given to Shirley Jackson

Shirley Jackson

Physics: The River that Runs Through It All

Monday, August 2
11:30 a.m.–12:30 p.m.

Dr. Shirley Ann Jackson has been named as the 2021 recipient of the prestigious Hans Christian Oersted Medal, presented by the American Association of Physics Teachers (AAPT). The Oersted Medal recognizes her outstanding, widespread, and lasting impact on the teaching of physics through her pioneering national leadership in physics education, her exceptional service to AAPT, and her mentoring of students and in-service teachers.

Dr. Jackson, President of Rensselaer Polytechnic Institute, is a theoretical physicist. She has had a distinguished career that includes senior leadership positions in academia, government, industry, and research. She holds an SB in Physics, and a PhD in Theoretical Elementary Particle Physics—both from MIT. She is the first African American woman to receive a doctorate from MIT—in any field—and has been a trailblazer throughout her career, including as the first African-American woman to lead a top-ranked research university.

After receiving her degree, Jackson was hired as a research associate in theoretical physics at the Fermi National Accelerator Laboratory, or Fermilab. While at Fermilab, she studied medium to large subatomic particles, specifically hadrons, a subatomic particle with a strong nuclear force. In 1974, after two years with the Fermilab, Jackson served as visiting science associate at the European Organization for Nuclear Research in Switzerland, and worked on theories of strongly interacting elementary particles.

In 1976, Jackson began working on the technical staff for Bell Telephone laboratories in theoretical physics. Her research focused on the electronic properties of ceramic materials in hopes that they could act as superconductors of electric currents. That same year, she was appointed professor of physics at Rutgers University. In 1980, Jackson became the president of the National Society of Black Physicists and in 1985, she began serving as a member of the New Jersey Commission on Science and Technology.

In 1991, Jackson served as a professor at Rutgers while working for AT&T Bell Laboratories in Murray Hill, New Jersey. In 1995, she was appointed by President Clinton to the chair of the Nuclear Regulatory Commission. In 1997, Jackson led the formation of the International Nuclear Regulators Association. In 1998, she was inducted into the National Women's Hall of Fame; the following year, she became the eighteenth president of Rensselaer Polytechnic Institute. Jackson remains an advocate for women and minorities in the sciences and, since 2001, has brought needed attention to the "Quiet Crisis" of America's predicted inability to innovate in the face of a looming scientific workforce shortage.

In 2015, Jackson received the inaugural Alice H. Parker Award from the New Jersey Chamber of Commerce, which honors women leaders in innovation. In 2016, United States President Barack Obama awarded her the National Medal of Science, the nation's highest honor for contributions in science and engineering.

In 2018, she was awarded the W.E.B. DuBois Medal from the Hutchins Center for African and African American Research at Harvard University. The medal honors those who have made significant contributions to African and African American history and culture, and more broadly, individuals who advocate for intercultural understanding and human rights in an increasingly global and interconnected world.

ABSTRACT: Shirley Ann Jackson will discuss her own educational path, which led her to a doctorate from MIT in theoretical elementary particle physics, and the ways that her research career in condensed matter physics expanded into government, corporate, and academic leadership roles at the highest national levels. She will consider "the Quiet Crisis", America's national need to bring women and underrepresented minorities into STEM fields in sufficient numbers, while continuing to attract talent from abroad. She will offer observations and ideas for the ways that the nation's physics teachers can help to bring the full talent pool into the field, as well as comment on the role of physics and physics-based education in creating a foundation for addressing complex global challenges – for individuals and collaborative groups.

The Oersted Medal recognizes those who have had an outstanding, widespread, and lasting impact on the teaching of physics. The recipient delivers an address at an AAPT Winter Meeting and receives a monetary award, the Oersted Medal, an Award Certificate, and travel expenses to the meeting. Self-nomination is not appropriate for this award. Preference in the selection of the recipient will be given to members of AAPT.

2021 Millikan Medal Awarded to Gregory E. Francis


Gregory Francis

Two Red Bricks: Is A Good Lecture Better Than No Lecture At All?

Monday, August 2
1–2 p.m.

Gregory E. Francis will receive the Robert A. Millikan Medal. This award recognizes educators who have made notable and intellectually creative contributions to the teaching of physics.

Francis is the Director of the Master of Science in Science Education Program at Montana State University, Bozeman, MT. This program offers a unique blend of online and field courses for K-12 educators. In its 23rd year, the program has produced over 1200 graduates.

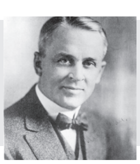
Francis is co-author of two introductory textbooks: *Physics: A Conceptual World View* with Larry Kirkpatrick, and *College Physics: Putting It All Together* with Ron Hellings and Jeff Adams. His BS in physics is from Brigham Young University and his PhD in physics is from Massachusetts Institute of Technology.

First and foremost a teacher, Francis began his work touching young minds early. As an undergraduate at Brigham Young University he taught recitation sections normally reserved for graduate students. Later, as a graduate student studying plasma physics at MIT, he regularly found opportunities to teach classes normally reserved for research faculty. After finishing his doctorate in 1987 he served as a postdoctoral fellow at Lawrence Livermore National Laboratories. Although his day job gave him the opportunity to work with world-class scientists on exciting problems, he found that he really preferred his night job, teaching physics classes at the local community college.

In 1990, Francis joined the Physics Education Research Group at the University of Washington-Seattle, working with Lillian McDermott and Peter Shaffer to explore the science of effective physics teaching. Since 1992 he has continued to experiment with active learning approaches in large introductory classes at Montana State University where he is currently Professor of Physics.

Regarding his recognition as recipient of the Millikan Medal Francis said, " I am deeply humbled, and also confused. I have worked with so many talented teachers over the years that are more deserving of this award. I guess I don't have to understand it to be grateful for it. I will accept the award as a representative of the many college physics teachers who try their best, year after year, to help their students appreciate the physical world around them."

ABSTRACT: It has been said that the typical lecture is every bit as effective as placing two red bricks in front of the class for fifty minutes. I have spent my teaching career trying to improve upon that baseline. I will discuss different techniques used in my large introductory algebra-based courses to make the lecture experience more active and student centered. I have found that using the lecture as a support platform built around the Tutorials in Introductory Physics by Lillian McDermott, Peter Shafer, and the Physics Education Group at University of Washington yields measurable gains in student conceptual understanding and retention.



The Robert A Millikan Medal recognizes those who have made notable and intellectually creative contributions to the teaching of physics. The recipient delivers an address at an AAPT Summer Meeting and receives a monetary award, the Millikan Medal, an Award Certificate, and travel expenses to the meeting. Self-nomination is not appropriate for this award. Preference in the selection of the recipient will be given to members of AAPT.

2021 Doc Brown Futures Award to Ramón Barthelemy

Ramón Barthelemy

Queering Physics Education Research: A History of Queer Rights in the USA and Physics

Wednesday, August 4
11 a.m.–12 p.m.

The recipient of the Doc Brown Futures Award is Dr. Ramón S. Barthelemy. 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.

"AAPT has been a critical part of my physics education research journey and I am very honored to have been nominated by my peers for this award. This community is full of amazing people who do forward thinking work to support People of Color, LGBT+, and other underrepresented physicists," said Barthelemy. A member of AAPT since 2011, Ramón Barthelemy is an early-career physicist with a record of groundbreaking scholarship and advocacy. He has advanced the field of Physics Education Research (PER) as it pertains to gender issues and LGBT+ physicists. Through service and advocacy, he has strengthened AAPT's efforts to broaden participation in physics.

Barthelemy earned his BS in Astrophysics at Michigan State University and his MA and PhD in Physics Education Research at Western Michigan University. He received a Fulbright Fellowship at the University of Jyväskylä, in Finland in 2014 and a AAAS Science Policy Fellowship in 2015. He is also the recent recipient of two National Science Foundation grants to continue his work on gender in physics but also expand it to people of color in STEM and graduate program reform.

He began his position as an assistant professor of physics and astronomy (P&A) at the University of Utah in 2019. He is the first tenure track PER faculty hired in P&A at "The U" and has begun their first PER research group, the Physics Education Research Group at the University of Utah (PERU). Barthelemy also teaches courses in calculus-based introductory physics and physics education.

His involvement with AAPT has included serving on the Committee on Women in Physics and organizing sessions for that committee as well as the Committee on Diversity. He was one of the early advocates for LGBT+ voices in AAPT, leading discussions and organizing the first AAPT session on the topic. He is also one of the authors of the APS report "LGBT Climate in Physics: Building an Inclusive Community." Though this work was not done under the auspices of AAPT, the report has been a valuable resource to many AAPT members—both those whose stories were being told for the first time, and others who want to improve their departments and workplaces for LGBT colleagues and students. He was also a coauthor on the first edition of the LGBT+ Inclusivity in Physics and Astronomy best practices guide, which helps to offer actionable strategies. He also recently published a peer-reviewed paper on this topic in the *European Journal of Physics* with more in review.

Barthelemy is a valued collaborator and can be relied on to challenge biases and inequities. He has been a leader in pushing forward Physics Education Researchers' understanding of gender and LGBT issues in physics.

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.

Homer L. Dodge Citations for Distinguished Service to AAPT

Alexis Knaub

Wednesday, August 4
11 a.m.–12 p.m.

Alexis Knaub

Regarding her selection to receive this citation, Knaub said, "I'm truly honored colleagues took the time to nominate me for this award. Being in community with so many amazing people in AAPT, many of whom I consider to be not just colleagues but collaborators and friends, has been an important part of my personal and professional life. My involvement in service wouldn't have been possible without others in many ways, and I'm grateful to be working with people who have changed my thinking and actions for the better. Thank you so much for this award."

Knaub earned her BA in Physics at Smith College. Her MS in Physics is from DePaul University and her EdD in Physics Education at Boston University. A member of AAPT since 2014, Knaub has made several excellent and multifaceted contributions to the organization. In 2017, she co-designed and co-created the People of Color in Physics Education Research discussion space and has been deliberate and intentional in designing this as a "safe" space, where scholars of color in PER can be themselves.

She co-authored the white paper, Emerging Reflections from the People of Color (POC) at PERC Discussion Space and supported the presentation of this paper as a poster at the Physics Education Research Conference (PERC) in 2019. The paper will continue to influence the discourse on race within the AAPT and PERC communities for many years.

Knaub has served as a Member (2019-20) and Vice-Chair (2020-21) of the Committee on Diversity, playing a crucial role in the design and creation of the Equity, Diversity, Inclusion (EDI) room at 2020 AAPT Virtual Summer Meeting. The EDI rooms provided a space for concerted talks and discussion around one of the most significant challenges facing physics education.

In 2020, Knaub co-organized the PER Conference while facing unprecedented challenges for conference organizers. Together with the other PERC Organizers, she took those challenges in their stride and was able to provide an excellent conference experience in spite of the pandemic, the last-minute move to online hosting, etc. Even before the conference, it was obvious that 2020 would offer a conference that was community oriented, rather than focusing on some research theme.

Designing, creating, and sustaining spaces that nurture community growth, that nurture scholars of color, and challenge racism requires a tremendous amount of emotional as well as intellectual labor. Knaub's research on social network theory aims to understand systemic change. Her publications add new insights to understanding the experiences of women in physics, and will help in the design of new pathways for encouraging and sustaining women's trajectories within physics and PER.

2021 AAPT Summer Fellows

The criterion for selection of Fellows is exceptional contribution to AAPT's mission, to enhance the understanding and appreciation of physics through teaching. Fellowship is a distinct honor signifying recognition by one's professional peers. Any AAPT member who has maintained an active membership for at least 7 years is eligible for nomination for Fellowship. Nominations are evaluated by the AAPT Awards committee and approved by the AAPT Board of Directors.

The 2021 Summer Fellows are:

Dan Burns, Cabrillo College, Aptos. CA

Doug Brown, Los Gatos High School in Los Gatos, CA

Angela White

Diversity, Equity and Inclusion Plenary

Tuesday, August 3
11 a.m.–12 p.m.

Dr. Angela M. White

Assistant Dean of Student Success, Office of Student Success, College of Science and Technology, North Carolina Agricultural & Technical State University

Dr. Angela Michelle White has an extreme passion for teaching and learning science. She earned a Bachelor of Science in Biology from the University of North Carolina at Chapel Hill, a Master of Science in Biology from North Carolina Agricultural and Technical State University, and a Doctor of Philosophy in Curriculum and Instruction with a concentration in Educational Psychology from North Carolina State University. Dr. White has served as an educator for 17 years at various levels and currently serves as the Assistant Dean of Student Success for the College of Science and Technology at North Carolina Agricultural and Technical State University. In this role she strategically develops and implements initiatives that promote the participation, academic achievement, and success of students within the College. Her current research interests, publications, and presentations give attention to racial identity, science identity, science self-efficacy, metacognition, and STEM achievement of African American students. As a strong advocate for the participation of African American females in STEM, Dr. White continuously engages in discourse and research that will promote greater access to STEM-related opportunities and recognition of African American females. Dr. White is also the co-founder of NoireSTEM, an educational consulting firm that seeks to increase access and achievement of African Americans in STEM degree programs and careers.

Justyn Zwolak

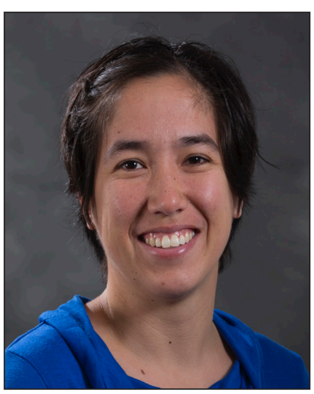
APS Plenary on Quantum Computing

Tuesday, August 3
2:15–3:15 p.m.

Justyn Zwolak, NIST

Justyna Zwolak is a scientist in the Applied and Computational Mathematics Division at National Institute of Standards and Technology in Gaithersburg, MD. She received an MSc in Mathematics from The Faculty of Mathematics and Informatics, Nicolaus Copernicus University, and a PhD in Physics from the Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, in TorunÌ, Poland. She subsequently was a research associate in the Department of Physics at Oregon State University, at the STEM Transformation Institute at Florida International University, and an assistant research scholar in the Joint Center for Quantum Information and Computer Science at University of Maryland, College Park, MD.

Her research pursuits range from quantum information theory and machine learning to complex network analysis to mathematics and physics education. In her current work, Justyna uses machine learning algorithms and artificial intelligence, especially deep convolutional neural networks, to enhance and control quantum system and quantum computing platforms. In particular, she is investigating methods to automatically identify stable configurations of electron spins in semiconductor-based quantum computing. She is also developing a complete software suite that enables modeling of quantum dot devices, training recognition networks, and—through mathematical optimization— calibrating and controlling experimental setups. Success in this endeavor will eliminate the need for heuristic calibration and help scale up quantum computing into larger system. She is also involved in studies on diversity and inclusion at NIST.



Kai-Mei

Kai-Mei C Fu, UW

Kai-Mei is an Associate Professor of Physics and Electrical and Computer Engineering at the University of Washington. She is the Director of the UW NSF Research Traineeship program Accelerating Quantum-Enabled Systems. Her research focuses on understanding and engineering the quantum properties of point defects in crystals, and utilizing these properties in photonic devices for quantum information and sensing applications. Kai-Mei Fu received her A.B. in Physics from Princeton University in 2000 and Ph.D. in Applied Physics from Stanford University in 2007.

Picture a Scientist Discussion

Tuesday, August 3
3:15–4 p.m.

PICTURE A SCIENTIST chronicles the groundswell of researchers who are writing a new chapter for women scientists. Biologist Nancy Hopkins, chemist Raychelle Burks, and geologist Jane Willenbring lead viewers on a journey deep into their own experiences in the sciences, ranging from brutal harassment to years of subtle slights. Along the way, from cramped laboratories to spectacular field stations, we encounter scientific luminaries—including social scientists, neuroscientists, and psychologists - who provide new perspectives on how to make science itself more diverse, equitable, and open to all.

Exhibitor List for Virtual Summer Meeting:

The exhibitors will be available to visit during the meeting at any time and during times noted in program!

AAPT Membership

Jerri Anderson; jbanderson@aapt.org

Members receive full online access to AAPT's journals, resources to use in your classroom/lab, and a subscription to *Physics Today*. Members also get discounts on meetings, The Physics Store, products and services in our Member Discounts Program, and more! Go to www.aapt.org for more information.

AAPT Publications

AAPT® publishes two peer-reviewed journals in both print and online. The *American Journal of Physics®* published 12 times per year, is geared to an advanced audience, primarily at the college level. Contents include novel approaches to laboratory and classroom instruction, insightful articles on topics in classical and modern physics apparatus notes, historical or cultural topics, and book reviews. *The Physics Teacher®* published nine times per year, focuses on teaching introductory physics at all levels. Contents include tutorial papers, articles on pedagogy, current research or news in physics, articles on history and philosophy, and biographies. Columns feature demonstrations, apparatus, and book reviews. AAPT® also publishes a series of books in partnership with AIP Publishing that focus on training and development resources for professionals and physics educators

Here are times you can click and meet the editors of AAPT's Journals:

Meet the Editor of *AJP:*

Sunday 12:00 – 12:30 pm
Monday 12:30 – 1:00 pm
Tuesday 12:00 – 12:30 pm

Meet the Editor of *TPT:*

Saturday 12:00 – 12:30 pm
Sunday 12:00 – 12:30 pm
Monday 12:30 – 1:00 pm

Maryann Gross; mgross@aipp.org

Pivot Interactives

Peter Bohacek; peter.bohacek@pivotinteractives.com

Decades of research shows people learn better when they are actively engaged rather than watching or listening. Pivot Interactives makes it simple for teachers to use active learning for science. Our collection of more than 400 activities engages students to explore, observe, make connections. Customized feedback guides students and lets teacher measure progress. Interactive video, hands-on learning with sensors, or interactive simulations: you'll have the best tool for every teaching scenario. Any science subject, anytime, anywhere.

PASCO Scientific

Brett Sackett; sackett@pasco.com

When you partner with PASCO, we work with you to develop engaging, hands-on investigations that help ignite student interest and improve learning outcomes. From world-class sensors and equipment to award-winning software and labs, PASCO solutions are thoughtfully designed and thoroughly tested to ensure success in your classroom, lab, or living room.

Society of Physics Students

Lydia Quijada; lquijada@aip.org

The Society of Physics Students (SPS) and Sigma Pi Sigma are chapter-based organizations that serves all undergraduate physics students and mentors in nearly every physics program in the country and internationally. We support scholarships, internships, outreach, research and more.

THOR Labs

Mary Erickson; Merickson@thorlabs.com

VRLAb Academy is an educational technology innovation company that produces virtual reality science experiments for educational purposes. It gives students access to a realistic lab experience that will let them perform experiments and practice their skills in an interactive, risk and pollution-free learning environment. Our software works with real formulas, actual results, it is compatible with science course syllabuses and available in different languages. Experiments work online with real time data which can be manually filled, saved in .csv format and shared. Our system has an error margin, so students will receive different results each time they perform experiments. Also, it is possible to integrate VRLab Academy in any LMS, as a consequence, it will help to save time, reduce manual tasks, make Single sign-on process possible and offer to educators access to students performance data.

Power your science curriculum with VRLab Academy experiments.

Vernier Software and Technology

Angie Harr; aharr@vernier.com

Vernier Software & Technology is the leading worldwide innovator of real-time data-collection, graphing, and analysis tools for science education. As the pandemic continues to disrupt education systems around the world, we want you to know we're here for you. We're working hard to ensure educators have the tools necessary to keep students engaged with science.

Join us for our live workshop on August 2 from 10:00-11:00 a.m. to learn more about how Vernier Video Analysis™ can help students stay engaged as they learn in-person or remotely. Students can use their mobile devices in the laboratory or out in the field to insert a video with recorded motion, mark points to track the object in motion, and set the scale of the video. Video Analysis generates accurate and visually rich graphs and a data table reflecting the recorded motion.

VRLab Academy

Emine Gundogan; sales@vrlabacademy.com

VRLAb Academy is an educational technology innovation company that produces virtual reality science experiments for educational purposes. It gives students access to a realistic lab experience that will let them perform experiments and practice their skills in an interactive, risk and pollution-free learning environment. Our software works with real formulas, actual results, it is compatible with science course syllabuses and available in different languages. Experiments work online with real time data which can be manually filled, saved in .csv format and shared. Our system has an error margin, so students will receive different results each time they perform experiments. Also, it is possible to integrate VRLab Academy in any LMS, as a consequence, it will help to save time, reduce manual tasks, make Single sign-on process possible and offer to educators access to students performance data.

Power your science curriculum with VRLab Academy experiments.

Here, in VRLab Academy, we try to help educators and students take the best of physical and online learning. Because we believe that hybrid learning is the future of education. While physical teaching will remain an essential part of education, we all now see the need to open up multiple digital engagements to respond to not only extreme conditions but also everyday interruptions of effective education. Our software is not a replacement of real laboratories but an additional tool in making learning more accessible, engaging and personalized to the diverse learners.

https://www.youtube.com/watch?v=04m-hBYNByk

Also you can easily set up a demo meeting with VRLab Academy through our website. Our team including a member from our science department will be happy to walk you through our system, answer all your questions and showcase our experiments.

https://vrlabacademy-vrlabacademy.zohobookings.com

Exhibitor Virtual Commercial Workshops

VRLab Academy, Science Laboratories within Your Reach

Saturday, July 31 2–3 p.m.

VRLab Academy makes it possible to perform scientific experiments using your PC or VR devices. Users can perform curriculum based experiments that rely on real scientific data. We will be providing information about our platform, its content and also demonstrate an experiment to attendees for their better understanding. Attendees will have 3 day access to the platform and will be able to perform 3 experiments during this time.

Vernier Software and Technology: Vernier Video Analysis on Chromebooks, Computers, and Tablets

Monday, August 2 10–11 a.m.

Quickly and easily analyze videos in our Vernier Video Analysis app for ChromeOS, macOS, Windows, iOS and Android. We'll demonstrate how to analyze motion with this feature-laden app, apply vectors to motion trails, convert data to polar coordinates, and add center of mass data to collision videos and graphs. Limited-time free-access codes to Vernier Video Analysis and Graphical Analysis Pro will be provided to attendees.

THORLabs: Time-Resolved Absorption Spectroscopy with Nanosecond Lasers

Monday, August 2 3–4 p.m.

Join us on August 2nd at 3:00 p.m. EDT for a demonstration of Thorlabs' upcoming Time-Resolved Absorption Spectroscopy Kit. Developed in collaboration with Heidelberg University and designed for use in the classroom, the kit uses Thorlabs' pulsed nanosecond lasers to measure electron transfer times and the effectiveness of electron transfer between fullerenes.

AAPT Publications

Tuesday, August 3 10–11 a.m.

Curious to learn more about what it takes to become a published author? Want to be in the know with the book publishing partnership with AIP Publishing? Join us on Tuesday, August 3rd, 2021, at 10:00 a.m. for a panel discussion workshop to learn more about the book publishing process with AAPT and AIP Publishing! You'll hear from AAPT Books Chairperson Laura McCollough and AIP Publishing's Commissioning Editor, Lauren Schultz, about the partnership, and they'll share some inside information about the publishing process. AAPT members and authors Jim Nelson (Teaching about Magnets and Magnetism and Teaching About Geometric Optics) and Rebecca Vieyra (Teaching High School Physics) will share their expertise in writing textbooks and their experiences working with the teams at AIP Publishing. Come and hear about: • What fellow members have to say about the triumphs and challenges of the writing process • How to get started on your book proposal and get some tips from an expert • Benefits of the book partnership for AAPT members.

PASCO scientific: Applying Computational Thinking in the Physics Classroom

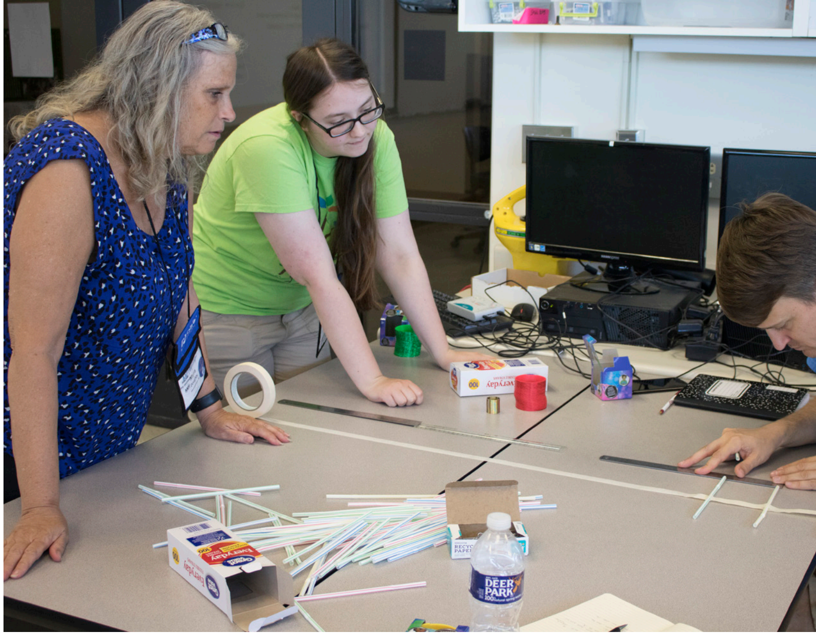
Tuesday, August 3 12–1 p.m.

Coding is providing physics educators new opportunities to deepen student understanding. Join us in this workshop for an exciting look at using PASCO Capstone software and computational modeling to teach a variety of more complex physics concepts, like simple and physical pendulums (with/without air drag), projectile motion (with/without air drag), Newton's law of cooling, and the forces and motion of a falling chain — we'll show you how to engage students in computational thinking as they build data sets based on theoretical models, and then test that data with hands-on equipment.

Pivot Interactives: One-stop Solution for Active Learning

Wednesday, August 4 10–11 a.m.

Pivot Interactives makes active learning easy. Choose from three online active learning modes: interactive video, hands-on data with Bluetooth sensors, and simulations. Select from our library of hundreds of pre-made activities, modify as needed, or create your own. Automatic feedback and scoring, LMS integration, and randomization ensure easy and accurate grading. Come learn how Pivot Interactive makes active learning efficient and effective.



DEI Resource Room Schedule

TIME	WHAT	WHO
Sunday, Aug. 1, 12–1 pm	Beyond the Land Acknowledgement: Engaging Indigenous Physicists	Ximena Cid and Xandria Quichocho
Sunday, Aug. 1, 1–2 pm	The Complexity of Bodies: Navigating the Intersection of Queerness and Disability	Dan Oleynik
Sunday, Aug. 1, 2–3 pm	The pandemic and its impact on women	Laura McCullough and Emily Marshman
Monday, Aug. 2, 10–11 am	OPEN	
Monday, Aug. 2, 2:15–3:15 pm	LGBTQ+ Discussion	Ramón Barthelemy
Monday, Aug. 2, 2:45–3:45 PM	Department Action Teams	Gina Quan and Joel Corbo
Tuesday, Aug. 3, 10–11 am	Inclusive Curriculum in Physics	Mel Sabella
Tuesday, Aug. 3, 1–2 pm	After session discussion of Angela White's talk	Alexis Knaub
Tuesday, Aug. 3, 12:30–1:30 pm	DEI and TYC	Negussie Tirfessa
Wednesday, Aug. 4, 10–11 am	AAPT and the Societies Consortium on Sexual Harassment in STEMM's "Roadmap Towards Excellence & Integrity in STEMM"	Beth Cunningham
Wednesday, Aug. 4, 12:30-1:30 p.m.	Asian Americans in Physics	David Marasco and Alexis Knaub
Wednesday, Aug. 4, 1:30–2:30 pm	OPEN	

K-12 Lounge Schedule

TIME	WHAT	WHO
Sunday, Aug. 1, 10 a.m.	**Session Title: The Role of Assessments Post-COVID** This past year has led us to reconsider how we assess in our classrooms. In an era where most information can be found online and is easily accessible, we need to consider changing how and what we assess. This session is intended to share resources amongst teachers and to view examples of different methods of assessment for the upcoming school year.	Debbie Andres
Sunday, Aug. 1, 7 p.m.	**K-12 Social Hour**	
Monday, Aug. 2, 2:15 p.m.	**Session Title: Are my students ready for college Physics?** Join a panel discussion of undergraduate students discussing how their high school physics experience did and did not prepare them for college.	Alan Wright
Monday, Aug. 2, 6 p.m.	**K-12 Social Hour**	
Tuesday, Aug. 3, 12 noon	**Session Title: Teacher Town Hall: Bringing Quantum Information Science to K-12** High school science teachers are invited to participate in this fun, informative "town hall" event to discuss quantum information science and the benefits and challenges of introducing this topic to their students. In this interactive session we will gather input on future activities, such as Quantum Crossing, an event being held in October to showcase what different careers in QIS look like to high school students. This event is the second in a series held in Summer 2021. The first activity was organized in partnership with APS and the National Q-12 Education Partnership.	Emily Edwards
Tuesday, Aug. 3, 5 p.m.	**K-12 Social Hour**	

AAPT AWARDS

Presider: Chandralekha Singh

Klopsteg Lecture Award: Dr. Helen Czerski

An Ocean of Physics

When the Apollo astronauts travelled to the Moon, the most memorable photograph they took was of the “Blue Marble”: the view of Earth from space. It was undeniable recognition that the blue – the ocean - is the defining feature of our planet. When you look at the physics of Earth, the ocean engine also dominates the story. This talk will be about the physics of the ocean, and the perspective on our planet that we get from exploring it. Zooming in from the very large, we’ll get to the very small: the breaking waves and bubbles that are found at the ocean surface. These bubbles help the ocean breathe, and my research is focussed on understanding how they form, and how they help that breathing process. But before you can study them, you need to work out how to measure them, so we’ll also cover the ways to use sound and light to detect bubbles that are too small to see, or too fleeting to catch. The ocean is full of adventures, and we’re really only at the start.

Helen Czerski

Saturday, July 31
11 a.m.–12 p.m.

Session: PS.A-SA-1 Achievement Gaps During Online Instruction: Lessons Learned **Saturday, July 31, 12:30–1:45 p.m**
Sponsors: Committee on Physics in Two-Year Colleges, Committee on Laboratories **Presider:** *Forouzan Faridian*

PS.A-SA-1.01: Creating Honest, Fair, and Equitable Remote Introductory Physics Exams

Contributed – Melanie Good, University of Pittsburgh

Due to the COVID-19 pandemic, many universities have had to transition to online instruction and use online forms of assessment. For large-enrollment introductory physics classes, this situation raises questions of how best to ensure academic honesty and also how to ensure fairness and digital equity. In this investigation, the prevalence of academic dishonesty via unauthorized information sharing was explored in several remote large-enrollment introductory physics courses. Additionally, students were surveyed regarding their experience with exams. Potential issues of fairness and digital equity are revealed in the survey results. These issues as well as corrective measures taken are described, along with follow-up input from students.

PS.A-SA-1.02: Demographic Gaps in Achievement Caused by COVID-induced Campus Closure

Contributed – Tom Zhang, ,Zhongzhou Chen, University of Central Florida

With the sudden onset of campus closure by COVID-19, the transition to a fully online course modality brings into question the efficacy of distance learning and the implementation of these online learning environments. In particular, we are looking to explore the potential gaps in learning and engagement in demographic groups, caused or at least agitated by the shift into these environments.

PS.A-SA-1.03: Standards-based Grading Without Exams for Online Instruction

Contributed – Cory Christenson, Washington & Jefferson College

In response to student difficulties with staying motivated during online classes, I eliminated exams from Introductory E&M and introduced a standards-based grading approach to the homework. The goals were to relieve stress and highlight that consistent motivation is key to success. This scheme was supported with points for participation and reflection of students' own approach to problems solving. The strategy that the students are asked to take to the class is also more consistent with how professionals address problems. The hope was that this would provide strong incentive to stay continuously engaged throughout the semester. I will talk about my implementation of this, how the students responded, and what I learned about student motivation and success.

PS.A-SA-1.04: Combining OER Resources with Online Simulations to Reduce Achievement Gap

Contributed – Moe Tabanli, Meenu Jain, Middlesex County College

The cost of the textbook is sky rocketing and sometimes it does not fit to the needs of students. Especially General Education Physics textbooks seems a simplified version of Calculus based textbooks. Which is a service to students who needs enrichment but a disservice to underprepared students. At Middlesex County College using an Open Educational Resources grant, we developed a workbook which focusses on proficiency on specific learning outcomes. Remote teaching furthermore gave us an opportunity to match specific problems with online simulations. Every topic starts with a model system or phenomena with the goal of determining the outcome using the inputs. Concepts and theories are clearly outlined during the lecture followed by in class problem solving sessions with group work and engagement with the instructor. Integrating OER with online simulations saves money, time and it enables students to be more focused and more confident.

PS.A-SA-1.06: Students' Differential Experiences with Emergency Remote Teaching in Fall 2020

Invited – Michael Vignal, University of Colorado Boulder

Bethany R. Wilcox, University of Colorado Boulder

Erin M. Scanlon, University of Connecticut

Jacquelyn J. Chini, University of Central Florida

In response to the COVID-19 pandemic, the majority of US colleges and universities chose to continue teaching and rapidly switched to a new mode of instruction that we call Emergency Remote Teaching (ERT). As ERT is different from traditional online learning in scope and intention, it is important to understand student experiences with ERT to better inform ERT instruction (and potentially more traditional instruction as well). Student experiences with ERT cannot be separated from the social and political strife that accompanied it (especially in the US), nor can they be separated from systems of oppression that discriminate based on gender, race, ability, and other factors. In this talk, we explore differential experiences with and impacts of ERT across more than 1700 students enrolled in college and university physics courses in the US in the fall of 2020.

PS.A-SA-1.07: Decolonizing the Physics and Astronomy Classroom

Invited – Jorge Moreno Soto, Pomona College

In this talk I will present a blueprint for decolonizing the classroom. Rather than adhering to the traditional classroom, we create an anti-hierarchical collective where the most marginalized voices are prioritized. To achieve this, we implement the following key pillars: (1) Justice education as one of the main ingredients in the curriculum. (2) Community town halls to address and improve the classroom climate. (3) Accountability systems through regular (anonymous) surveys collected and evaluated by an external paid expert. (4) Community building events to build trust as a cornerstone for accountability and mutual solidarity. (5) A decolonizing physics and astronomy symposium at the end of the semester, where the collective has an opportunity to share the lessons learned with the broader community. These methods are inspired by Zapatismo (Chiapas, Mexico) and implemented at Pomona College, a selective liberal arts college in the United States.

PS.A-SA-1.08: Creative Astronomy: Broadening the Scope of a Course in Astronomy*

Contributed – Joann Roberts, Chicago State University

Mel S. Sabella, Chicago State University

In the Fall 2020 semester, the Learning Assistant and instructor for the online general education astronomy course collaborated on instructional material development. Through activities that incorporated creativity, the arts, current events, and diverse representation, we were better able to support the course's learning objectives and outcomes as well as promote the mission and values of our institution. Activities included students creating and naming constellations and exoplanets of their own, facilitating discussions from scientists of color in TED talks, influencing feedback from the LA's poetry about astronomy and life, and reflecting on how science connects to society, culture and people. Just as creativity can serve as a bridge between science, self-reflection and expression, LAs serve as a bridge between instructors and students and bring complimentary experience and expertise to the learning space. This work highlights how LA-instructor collaboration can benefit classroom effectiveness, student engagement and student success.

Close, E. W.; Conn, J.; Close, H. G. Becoming Physics People: Development of Integrated Physics Identity through the Learning Assistant Experience. Physical Review Physics Education Research 2016, 12 (1), 010109–1– 010109–18, DOI: 10.1103/PhysRevPhysEducRes.12.010109

Davenport, F.; Amezcua, F.; Sabella, M. S.; Van Duzor, A. G. Exploring the Underlying Factors in Learning Assistant - Faculty Partnerships. 2017 Physics Education Research Conference (PERC) Proceedings 2017, 104– 107, DOI: 10.1119/perc.2017.pr.021

*Partially funded by the National Science Foundation (DUE# 1911341) and the Department of Education.

Session: PS.A-SA-2 Back to the Moon, and off to Mars Saturday, July 31, 12:30–1:45 p.m

Sponsors: Committee on Physics in Two-Year Colleges, Committee on Space Science and Astronomy Presider: *Toby Dittrich*

PS.A-SA-2.01: NASA's Artemis Program

Invited – Clark Esty

NASA's Artemis program represents a bold vision that will lead humanity forward to the Moon and prepare us for the next giant leap: human exploration of Mars. Through Artemis, with help from commercial and international partners, NASA will develop core capabilities at the Moon, incrementally working toward a sustained lunar presence and validating capabilities for human missions to Mars. Artemis will leverage Commercial Lunar Payload Services to deliver assets to the Moon, Space Launch System and Orion to launch crews to the Near Rectilinear Halo Orbit (NRHO), Human Landing System to transfer the crew between NRHO and the lunar surface, and Gateway to enable sustainable operations. After establishing these capabilities, NASA will continue working with commercial and international partners to establish the Artemis Base Camp near the lunar South Pole. With operational confidence gained from long-term lunar surface missions, humanity will be ready to send humans to the Red Planet.

PS.A-SA-2.02: Physical and Technical Challenges for Human Missions to Mars

Invited – Nehemiah Williams, National Aeronautics and Space Administration (NASA)

The Artemis missions to the Moon are setting the technical and operational stage for the first human missions to Mars as early as the 2030s. These future missions will require the successful transportation of crew, life support systems, and hardware across millions of miles of planetary distance. Furthermore, the propellant mass that is required to deploy hardware and infrastructure from Earth in support of crewed Mars missions is sensitive to the relative planetary alignments between the two planets. The favorable planetary alignment between Earth and Mars (known as opposition) occurs every 26 months, and the most favorable opposition opportunity occurs every 15 years (known as a synodic period). This presentation will discuss how the orbital mechanics between Earth and Mars strongly influence the many aspects of planning human missions to Mars, including transportation of crew, hardware and surface infrastructure, as well communication between Earth and Mars.

PS.A-SA-2.03: Using Commercial Services to Get to the Moon

Invited – Chris Culbert, NASA

The NASA Commercial Lunar Payload Services (CLPS) contract is continuation of the agency's strategy to rely on commercial companies to enable space exploration. Following the path already started with Commercial Cargo and Commercial Crew services for the International Space Station, CLPS is working with both small and large American companies to deliver NASA payloads to the surface of the Moon. Since no commercial company has landed on the Moon yet, this approach entails interesting approaches towards contracting for services and managing risk. To date, NASA has tasked 4 companies with delivering 6 sets of NASA payloads to the Moon with the first deliveries scheduled for late 2021.

PS.A-SA-2.04: NASA's New Rocket to the Moon, Mars, and Beyond

Invited – Rob Stough

NASA is launching a new generation of missions to the Moon — the Artemis program — and SLS will be the ride for the astronauts in their new spacecraft, called Orion. Towering 322 feet tall and generating more than 8.8 million pounds of thrust — more than the mighty Saturn V that sent the first generation of astronauts to the Moon during the Apollo program of the 1960s — SLS is currently being assembled at Kennedy Space Center in Florida. Launch of the uncrewed Artemis I test flight is scheduled for late 2021. Following the Artemis I test flight, launches with astronauts will begin and include a 21st-century landing on the Moon, as well as construction of a new lunar science outpost, called the Gateway.

Session: PS.A-SA-3 Best Practices for Developing Scientific Thinking, Reasoning, and Decision-Making Abilities Saturday, July 31, 12:30–1:45 p.m Sponsors: Committee on Physics in Two-Year Colleges, Committee on Laboratories Presider: *Krista Wood*

PS.A-SA-3.02: Stop Saying "Zero Gravity"?

Contributed – Padman Ganesh

The term "zero gravity" first appeared in NASA's technical bulletins in 1968. Since then "zero g" has become extremely common in popular usage. We also often hear talk of astronauts on the International Space Station (ISS) being weightless or experiencing zero gravity. I present here preliminary results of a survey conducted on social media of college students in the U.S who have taken a physics course in high school or college. Participants were asked about their familiarity with "zero g" or "zero gravity" and also if they thought that astronauts float because of zero gravity. The results show that a very high percentage of students surveyed are aware of the term. Significant numbers among them think that astronauts float due to the absence of gravity, a belief that does not appear to be based on a conceptual understanding of free fall/circular motion and scientific reasoning.

PS.A-SA-3.03: Decision-based Learning in Conceptual Newtonian Mechanics

Contributed – M. Jeannette Lawler, Brigham Young University

Ken Plummer, Brigham Young University

David F. Feldon, Kaylee Liston, Soojeong Jeong, Utah State University

Decision based learning (DBL) is a heavily scaffolded constructionist methodology. It guides students through complex cognitive tasks using a decision tree developed from expert approaches to problem solving. DBL was used to teach conceptional Newtonian mechanics in an online, on-demand, general education science course. This talk will introduce the methodology, explain why it was chosen to provide instructional framework for conceptional Newtonian mechanics, and provide results on the impact of a pilot trial of the technique on student performance both on conceptual Newtonian problems and Lawson's Classroom Test of Scientific Reasoning.

PS.A-SA-3.04: Investigating Student Decision Making When Engaging in Data Cleaning

Contributed – Adrian Adams, University of Utah

Lauren A. Barth-Cohen, Jason M. May, University of Utah

Inquiry-based physics labs often include a focus on collecting and analyzing scientific data. During the process of making sense of data, students often engage in data cleaning, even if not explicitly instructed. We define data cleaning as the process of identifying and mitigating instances in the data that are misaligned with expectations or hypotheses of the experiment, often due to equipment or software bugs. Our research analyzes think-aloud interviews from thirteen students and observational data in a first-semester, undergraduate IPLS lab. Qualitative coding focused on students' decision-making processes while engaging in data cleaning. Results show that students typically follow a process of noticing an outlier, reasoning about its cause, and then either keeping or discarding the outlier. Although determining the source of outliers in data is complicated, unpacking students' decision-making process is important for lab instructors to better support students in learning how to work with and interpret data.

PS.A-SA-3.05: Improving Teaching Methodology for an Electronics Lab Course

Contributed – Mugdha Polimera, University of North Carolina at Chapel Hill

Duane Deardorff, Sean Washburn, University of North Carolina at Chapel Hill

We present the improvements made to the teaching methodology for a required advanced electronics lab course for physics and astronomy majors at UNC-CH. The course had the reputation of being most challenging for our majors, leading to depleted student morale, and even losing physics majors. The primary concern was that students were focusing too much time and attention on the equipment and mechanics of the labs at the cost of understanding the underlying electronics principles. Our course changes include (1) updating the traditional lab format to worksheets to be completed in small groups, (2) including more circuit simulations and coding to foster conceptual understanding, and (3) dedicating time in each lab for mini-lectures to reinforce or introduce ideas that were missed in the lecture portion of the course. We present results from these changes to teaching practices and the benefits that we have achieved.

PS.A-SA-3.06: Development of a Modeling Framework for Assessment of Scientific Reasoning

Invited – Lei Bao, The Ohio State University

Kathleen Koenig, University of Cincinnati

Scientific reasoning has been emphasized as a core ability of 21st century education. For decades the only assessment instrument available for large-scale application was Lawson's Classroom Test of Scientific Reasoning, but the instrument has demonstrated validity weaknesses and ceiling limitations. As a result, there is urgent need for the development of a valid and updated scientific reasoning assessment instrument that is based on a coherent model and targets the wide-ranging skills required for 21st century learners. This talk reports on the development of a comprehensive modeling framework for scientific reasoning along with a new assessment instrument. The validity and reliability of the instrument, which have been established based on large-scale assessment outcomes, will also be discussed.
*Partially supported by the NSF DUE-1712238.

PS.A-SA-3.07: Teaching Magnetism the Child of Nursery School, by inquiry

Contributed – Amalia Maria Kontokosta, Faculty of Education School of Early Childhood Education Aristotle University of Thessaloniki

We helped children to understand properties of magnets not as an established body of knowledge, but rather as an active process of inquiry in which they can participate. Results and Conclusions : The results of our research were compared with a control group of students of Nursery school of Attica. Research Methodology: This work is an attempt to follow research steps forth by inquiry – based learning: a) trigger of interest, b) reminding of basic knowledge/formulation of hypothesis, c) experimentation/trials d formulation of conclusions, e)applications/generalization according to learning.

Session: PS.A-SA-4 Explaining Frontiers & Modern Technology Saturday, July 31, 12:30–1:45 p.m
Sponsors: Committee on Science Education for the Public, Committee on Contemporary Physics Presider: *Dawson Nodurft*

PS.A-SA-4.01: Relativity to Muons with Physics and Dance

Contributed – Sarah Demers, Emily Coates, Yale University

Modern physicists and modern choreographers each investigated Energy, Space and Time throughout the 20th century. While modern physics considered length contraction, time dilation, and ideas like the Higgs boson, modern dance artists experimented with spatial organization, duration in performance, and the relationship between the performer and the audience. We, a particle physicist and a dancer/choreographer, have developed a curriculum (included in our 2019 book published by Yale

University Press, "Physics and Dance") that uses these advances in each discipline to illuminate the other. We present several case studies from our curriculum and show how learning the similarities and contrasts between developments in modern physics and those in modern dance help students wrestle more deeply with the ideas in each discipline.

PS.A-SA-4.02: Using the Language of Quantum Mechanics to Explain Holographic Duality

Contributed – Sophia Domokos, New York Institute of Technology

Robert Bell, Trinh La, Patrick Mazza, New York Institute of Technology

Holographic duality represents a revolutionary new way to tackle strongly coupled systems like QCD at low energies, where quarks and gluons clump into mesons and baryons. The duality posits that low-energy QCD is equivalent to a weakly coupled system in a curved high-dimensional spacetime, where we can use standard perturbative techniques to make predictions for quantities like meson masses and couplings. While the original formulation of the duality relies on string theory, many techniques derived from it can be boiled down into problems readily accessible to undergraduates. In this talk, we show that finding the meson spectrum using holographic duality amounts to solving a one-dimensional Schroedinger equation, where the structure of the 5D curved space is encoded in the Schroedinger potential. We also highlight how our formulation can be used to provide students with intuition for the meaning of curved space.

PS.A-SA-4.03: Teaching Quantum Mechanics and Quantum Information to High School Students

Invited – M. Suhail Zubairy, Texas A&M University

In this talk, I address the question whether it is possible to convey the basic concepts of quantum mechanics and its amazing applications to someone with only a high school background of physics and mathematics. In the fall of 2018, I offered a course on Quantum Mechanics to incoming freshman students at the Texas A&M University. These students, just out of high school, took this course before they took the usual Mechanics and Electricity/Magnetism courses. I shall present the details of this course which covered not only the foundations of quantum mechanics including wave-particle duality, coherent superposition and entanglement, aspects of Einstein-Bohr debate, and Bell theorem, but also some mind boggling applications, such as in quantum communication and quantum computing. In 2020 I published a book (Quantum Mechanics for Beginners – with applications to Quantum Communications and Quantum Computing, Oxford University Press 2020) based on lecture notes for this course.

PS.A-SA-4.04: Can You Surf a Gravitational Wave? Explaining LIGO Science*

Invited – Amber Stuver, Villanova University

The first detection of gravitational waves (GW) by LIGO (Laser Interferometer Gravitational-Wave Observatory) has sparked new interest from physics and astronomy students in the often explosive processes and exotic objects that can be observed. This presentation will introduce the science of what GWs are and how LIGO detects them. We will also discuss several detections of gravitational waves, including describing the sources that created the GW. Most importantly, we will discuss how you can make connections between the science of GW and the concepts you are teaching in your high school and college classrooms. A summary list of resources will be provided, many of which will also be appropriate for public outreach purposes.

* This talk is presented on behalf of the LIGO Scientific Collaboration.

PS.A-SA-4.05: Information Technology: Challenges and Bottlenecks

Invited – Alexey Belyanin, Texas A&M University

Although the technology that enables the modern Information Age looks very complicated, it has several basic physics ideas at its core that are simple enough to explain at the high school level. One can use the same simple physics arguments to explain the fundamental limits of current information technologies and the bottlenecks we are already experiencing when we try to send, receive, or process information. Perhaps most importantly, after learning these basic physics principles, the students should be able to think about ways to overcome the challenges and propose their own solutions.

Session: PS.A-SA-5 Graduate Student Education in PER   Saturday, July 31, 12:30–1:45 p.m

Sponsor: Committee on Graduate Education in Physics   Presider: *Jennifer Blue*

PS.A-SA-5.01: Examining the Impact of Outreach Programs on Grads versus Undergrads

Contributed – Jonathan Perry, University of Texas at Austin

Callie Rethman, Jonan Donaldson, Tatiana Erukhimova, Texas A&M University

Recent studies have begun to explore the connection between physics identity development and career skill development with the facilitation of informal physics programs by our students. Informal physics programs, or outreach programs, provide pathways for less structured, voluntary engagement with the field, beyond the formal spaces of a classroom or laboratory, where students can explore their passions within the field. This work narrows the focus of previous work to explore the differences in experiences between graduate and undergraduate students from facilitating at least one of five outreach programs at a large, public university in Texas. Results from this work may help inform departmental efforts regarding retention, inclusion, and structures to promote skill development beyond the classroom.

PS.A-SA-5.02: Graduate Students and Departmental Practices: Concerns During COVID-19

Contributed – Christopher Porter, The Ohio State University

Geoff Potvin, Florida International University

Galen Pickett, California State University Long Beach

The COVID-19 outbreak introduced unexpected barriers and uncertainties for prospective graduate students and physics departments. Chief among the emergent concerns are the health and safety of students and faculty, continuation of graduate programs and the financial worries (of both students and departments) . These concerns may significantly disrupt application and admittance processes; of particular concern is potential impacts on the diversity of incoming graduate cohorts. Between fall 2020 and spring 2021, we conducted surveys of students and physics departments and follow-up interviews with both groups. In this talk, we will report on the ways in which COVID-19 has impacted the processes, pressures, and demographics of physics graduate programs, and also on the primary concerns that emerged among first-year graduate students. We will present practices implemented by departments, with special attention paid to those that have been successful in maintaining the size, diversity, and preparedness of the 2020 graduate cohort.

Acknowledgements: This project is supported by the American Physical Society's Innovation Fund.

PS.A-SA-5.03: Attitudinal and Motivational Factors in Graduate Students: Correlations and Disparities

Contributed – Christopher Porter, The Ohio State University

Andrew Heckler, The Ohio State University

For the past four years, researchers at OSU have been collecting attitudinal and motivation 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 these factors have not previously be studied at the graduate level. These factors include sense of belonging, physics identity, self-efficacy, and cost, among others. In this talk, we will focus on correlations between these factors, and similarities / disparities in scores between groups, including between underrepresented and overrepresented groups. We find many of the factors to be highly correlated with each other, and we find some to be correlated with milestones such as number of publications.

PS.A-SA-5.04: Graduate Reform in Physics and Astronomy: Tragedy, Policy, and Culture

Invited – MacKenzie Lenz, University of Utah

Ramón S. Barthelemy , University of Utah

Alexis Knaub, American Association of Physics Teachers

Many events can drive change but one hopes that a tragic event is not a primary motivator. Varied ideas about change regarding the graduate program circulated the Department of Physics and Astronomy at the University of Utah prior to 2017. But along with those ideas came resistance to change among the faculty, little sense of urgency, and an inability to settle or agree on the best course of action. However, when tragedy struck in the fall of 2017, change occurred at a much more rapid pace. In this talk we discuss the different aspects of the change process that transpired: spearheading events, decisions, departmental reaction, long-term impacts, challenges, guiding messages, and sense of community. One key finding we present is that, while policy change was widely implemented and accepted, there is still some resistance to cultural change within the department.

PS.A-SA-5.05: Vigyan Vidushi – A Programmatic Effort Towards Addressing Under-representation

Invited – Deepa Chari, Homi Bhbha Centre for Science Education, TIFR

Anwesh Mazumdar, Homi Bhbha Centre for Science Education, Mumbai, India

Vandana Nanal, Amol Dighe, Tata Institute of Fundamental Research

In physics discipline, women are globally underrepresented at the graduate level and at academic and top leadership positions in higher education institutes. It is argued that multiple stakeholders, including academic departments, management at higher education institutes, government, and scientific societies need to work in tandem on developing effective programs to recruit, retain, and advance women in physics in all under-represented areas. My presentation describes one such national programmatic effort - Vigyan Vidushi (a wise lady in science) recently launched in India by the Tata Institute of Fundamental Research and Homi Bhabha Centre for Science Education. It is a three-week summer school for the postgraduate physics degree pursuing women with a goal to enhance their preparedness towards graduate education and bring awareness of possible hindrances in career paths. The presentation will explore features of the Vigyan Vidushi Summer School in a case study model to understand its widescale utility and impact.

PS.A-SA-5.06: Using Deliberate Innovation to Understand Indifference in Graduate Advisor/Advisee Relationships

Contributed – Erika Cowan, Georgia Institute of Technology

Garrett Price, Michael Schatz, Georgia Institute of Technology

Advisors and graduate students are sometimes stuck and not moving their research forward. We use Deliberate Innovation(DI) techniques to understand the specific situations centered around research that graduate students and their advisors find themselves in that may be problematic. A critical element of this is determining whether advisors and advisees show indifference in particular situations. We understand indifference by noticing what people are and are not drawn to in the research setting, and will be focusing on ways in which we have seen it show up. Finding this indifference allows us to know where to focus our attention, with the ultimate goal of finding situations in which we can help graduate students and advisors get unstuck and move their research forward.

PS.A-SA-5.07: Making General Relativity More Accessible: The Generalized Geodesic Deviation Equation

Contributed – Isaac Waldstein, The University of North Carolina at Chapel Hill

The geodesic deviation equation (GDE) describes the tendency of objects to accelerate towards or away from each other due to spacetime curvature. The “standard” GDE treats the rate of separation of nearby geodesics as the same order in smallness as the separation itself. Relaxing this assumption (which is not discussed in textbooks) yields the generalized geodesic deviation equation (GGDE). We explore the GGDE on a two-sphere, by considering a fiducial geodesic and a secondary geodesic (both great circles) that cross at the poles. These geodesics are spanned by a “connecting geodesic”, whose tangent evaluated at the fiducial geodesic defines the separation vector. The second derivative of the separation vector describes the relative acceleration between these geodesics. Near the north pole, where the separation between these geodesics is small but the rate of separation can be large, we show that the GGDE holds but the GDE fails to apply.

PS.A-SA-5.08: Instructional Context for Astrophysics: Space Weather

Contributed – Ronald Freeman, SOSTC, AIAA

This paper expands on an AAPT 2018 presentation I gave on the disparity between global literacy and American literacy regarding Standard Model of Particle Physics. Whereas the Standard Model has typically been developed through experimentation within an artificially-produced electromagnetic environment, similar particle interactions have been detected with solar probes onboard satellites. The purpose of this paper is to contextualize the study of astrophysics, hence make the study relevant for learning reframed within the environment of space weather. Subatomic and/or ionized particle absorption in Earth atmosphere infrequently impacts global commerce. The relevance of astrophysics has implications not only for disruptions to radio and other telecommunications, power of electrical grids, GPS localizations and navigations but to the less frequently mentioned global warming. By illustrating the progression timeline in developing astrophysics according to real-world events and knowledge-building milestones, student self-reflection becomes the instructional process for further STEM-based education and vocational planning.

Session: PS.A-SA-6 PER: Assessment, Grading and Feedback I — Saturday, July 31, 12:30–1:45 p.m

Sponsor: AAPT **Presider:** *TBA*

PS.A-SA-6.01: Developing NGSS-aligned Assessment Tasks for the Next Gen PET Curriculum

Contributed – Steve Robinson, Tennessee Technological University

Paula Engelhardt, Meghan England, Tennessee Technological University

The Next Generation Physical Science and Everyday Thinking (NGP) curriculum materials [1] were developed to give students learning experiences that integrate all three dimensions of the Next Generation Science Standards (NGSS) [2]. Analysis of a subset of the materials with the EQUIP rubric [3] confirmed this alignment and integration. However, not surprisingly, analysis of the test bank questions that accompany the materials (using the 3D-LAP [4]) revealed that most items being used for assessment did not integrate the three dimensions. We are therefore developing assessment tasks that follow the pattern of NGP activities in integrating all three dimensions. In this presentation, we will describe the path that led us to this point, the process we are using to develop these assessment tasks, and preliminary results.

[1] https://nextgenpet.activatelearning.com

[2] NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

[3] https://www.nextgenscience.org/resources/equip-rubric-science

[4] Laverty, J. T., et. al., (2016). PloS ONE,11(9): e0162333.

PS.A-SA-6.02: Sources of Response Shift Bias in the CLASS's Real-World Connection

Contributed – Ivy Shaw, University of North Florida

William Paulger, Brendan McEnroe, Dr W. Brian Lane, Ian Crawford-Goss, University of North Florida

The Colorado Learning Attitudes about Science Survey (CLASS) assesses students' perceptions of physics through a self-reported agreement with attitudinal statements. Previous work shows CLASS results may be subject to response-shift bias, in which knowledge gained during an intervention causes learners' perceptions of their pre-instructional state to become more novice-like. We explored possible sources of this response-shift bias in the CLASS by asking students to (1) complete the survey twice at the beginning of the semester (providing their pre-instruction responses and expected end-of-semester responses) and twice at the end of the semester (providing their post-instruction responses and retrospective beginning-of-semester responses), and (2) comment on their concurrent responses. By comparing beginning-of-semester and end-of-semester comments with survey shifts from a broad sample of students, we illuminate an underexplored dimension of student thinking. Preliminary results show that our students expect their perceptions of the applicability of physics will grow directly from acquiring physics knowledge.

PS.A-SA-6.03: Tools for Identifying Effective Courses

Contributed – Jayson Nissen, Nissen Education Research and Design

Ian Her Many Horses, University of Colorado Boulder

Ben Van Dusen, Iowa State University

Manher Jariwala, Boston University

Eleanor W. Close, Texas State University

Educators and researchers often use research-based assessments to measure the efficacy of their courses. Limited resources exist, however, for interpreting assessment results. We will present analyses and representations created with data from more than 500 introductory physics courses that provide a context for interpreting assessment results. The data set comes from the online Learning About STEM Student Outcomes (LASSO) platform and the scientific literature. The representations include scatterplots of pretest and posttest scores and distributions of effect sizes, Cohen's d with Hedges' correction. These representations show how courses compare to the larger database before and after instruction. The results show that common rules of thumb for effect sizes are not useful for interpreting effect sizes on research-based assessments. Excel and R files are available at https://tinyurl.com/stemequityresources for readers to create their own visualizations overlaying their course data on the larger data set.

PS.A-SA-6.04: Optimizing the Length of Computerized Adaptive Testing for the FCI

Contributed – Jun-ichiro Yasuda, Yamagata University

Naohiro Mae, Osaka University

Michael M Hull, University of Vienna

Masa-aki Taniguchi, Meijo University

As a method to shorten the test time of the Force Concept Inventory (FCI), we suggest the use of Computerized Adaptive Testing (CAT). CAT is the process of administering a test on a computer, with items selected based upon responses to prior items. To develop a CAT–based version of the FCI (FCI-CAT), we examined the optimal test length of the FCI-CAT such that accuracy and precision of Cohen's d would be comparable to that of the full FCI for a given class size. We conducted a Monte Carlo simulation to analyze how the bias, standard error, and RMSE of Cohen's d depend upon the test-length. We found, that for a class size of 40, we may reduce the test length of the FCI-CAT to 15-19 items, thereby reducing the test time of the FCI to 50% - 63%, with an accompanying decrease in accuracy and precision of only 5-10%.

PS.A-SA-6.05: Students' Views of Experimental Physics in German Laboratory Classes

Contributed – Micol Alemani, University of Potsdam, Germany

Erik Teichmann, University of Potsdam, Germany

Heather J. Lewandowski, JILA and University of Colorado Boulder

The influence of physics laboratory courses on students' beliefs, attitudes, and expectations about the nature of experimental physics have been intensively studied in U.S. institutions using the Colorado Learning Attitudes Science Survey for Experimental Physics (E-CLASS). On the other hand, in Germany, the influence of laboratory courses on students' views of experimental physics is still unexplored. In this talk, we present how we translated the E-CLASS into German (the so-called GE-CLASS) and set-up a centralized automated system for instructors. Such a system, allows laboratory instructors of European German speaking countries to easily use the E-CLASS to assess the impact of their courses along this one dimension of learning. First results using the GE-CLASS at the University of Potsdam are presented. A comparison between the E-CLASS and GE-CLASS results for physics-major students is discussed.

PS.A-SA-6.06: Gaze Data Analysis in the Interpretation of Linear Graphs

Contributed – Sebastian Becker, Physics Education Research Group / University of Kaiserslautern

Lynn Knippertz, Stefan Ruzika, Optimization Research Group / KOMMS / University of Kaiserslautern

Jochen Kuhn, Physics Education Research Group, University of Kaiserslautern

The presented study investigates the use of mathematical procedures to solve items in a kinematic context. For this purpose, a validated test instrument by Ceuppens et al. (2019) was administered to high school students which included pairs of items in mathematics and kinematics contexts that are isomorphic to each other, i.e., have the same surface features. While solving the tasks, eye movements of N=35 learners were recorded by a stationary eyetracker. For selected items, we demonstrate that gaze behavior and thus visual strategies differ between solving the mathematical and kinematic items. The results show that specific solution strategies are induced by the task context, which means that procedures that can be applied in the mathematical context cannot be transferred to the kinematic context. The talk presents the study and discuss the results in details.

PS.A-SA-6.07: Research-based Assessment Feedback for Instructors

Contributed – Amali Priyanka Jambuge, Kansas State University

Katherine D. Rainey, Bethany R. Wilcox, University of Colorado Boulder

Amogh Sirnoorkar, James T. Laverty, Kansas State University

Assessment scores can be used to inform instructors about their students' learning, ideally to inform subsequent course modifications to better facilitate students' learning. However, explicit course modifications require interpretations about what assessment scores convey instructors about the extent to which students meet the learning goals instructors have for their students, i.e., actionable feedback for instructors (hereinafter feedback). As part of developing a standardized assessment for upper-division thermal physics, we articulate a theory-based approach to generating feedback that goes beyond simply reporting students' scores. The extent to which students met the learning goals instructors have for them guides our feedback generation. In this talk, we present our theory-based approach to feedback design by integrating effective feedback practices that promote instructors' agency. This work emphasizes the development of feedback for instructors to better facilitate students' learning in physics classrooms.

Session: PS.A-SA-7 Diverse Investigations I **Saturday, July 31, 12:30–1:45 p.m**

Sponsor: Committee on Research in Physics Education **Presider:** *TBA*

PS.A-SA-7.01: Roles in Collaborative Introductory Lab Activities

Contributed – Danny Doucette, University of Pittsburgh

Chandralekha Singh, University of Pittsburgh

To give our students the opportunity to learn collaboratively in our introductory physics labs, we developed a series of hour-long collaborative activities that students engaged with via Zoom using the IOLab lesson player. We envisioned and developed the activities to revolve around four student roles (experimentalist/theorist/archivist/manager) to help students share their work equally. By connecting student interviews with reports from 245 students who were randomly assigned to groups of 4 in each of 11 weeks for our activities, we find that roles helped improve the sharing of collaborative work online. However, there are two caveats. First, students did not allocate the roles equally. Second, write-ups from the groups with an isolated minority student (groups with one woman and three men) were significantly shorter than groups of any other configuration. These findings provide quantitative evidence to support longstanding advice that instructors should avoid forming groups with isolated minority students in physics.

PS.A-SA-7.02: Multilevel Module Analysis of the FCI

Contributed – Christopher Wheatley, West Virginia University

John Stewart, West Virginia University

Modified Module Analysis using partial correlations (MMA-P) has proven to be a productive method for studying conceptual inventories. MMA-P can be used to analyze large datasets by forming networks of responses then using community detection algorithms to identify sets of responses that are consistently selected together. MMA-P can be extended by using multilevel network analysis. A multilevel network was constructed with pretest and post-test Force Concept Inventory (FCI) responses from five different institutions using samples ranging from N=10,000 to N=200. Each layer of the multilevel network was represented by a network made from the application of MMA-P to data from each institution. Within each layer, MMA-P finds communities of popular responses. Network comparison methods were then used to understand the similarities and differences between the sets of nodes and communities in the networks. This provides insight into the generality of previously identified properties of the FCI between institutions.

PS.A-SA-7.03: Exploring Factors Influencing the Retention of Physics Majors

Contributed – John Stewart, West Virginia University

This talk examines the retention of physics majors at a moderately sized physics department which struggles with increasing the number of graduates using 20 years of graduation data. 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. Logistic regression is used to explore the factors related to retention in general and through the first two years of college. Decision trees, a method applied in machine learning, is used to quantify the thresholds of these variables important to evaluating risk.

PS.A-SA-7.04: Identifying Threats and Supports to Self-Efficacy Using Mixed Methods Research

Contributed – Carissa Myers, Department of Physics & Astrononym, Michigan State University

Vashti Sawtelle, Lyman Briggs College & Department of Physics & Astronomy, Michigan State University

Rachel Henderson, Department of Physics & Astronomy & CREATE for STEM Institute, Michigan State University

Research on self-efficacy— or the confidence in one's capability to perform a task — has been shown to predict achievement and persistence in the sciences. Throughout a student's experience in curricular and/or co-curricular activities, they may face threats to their self-efficacy. To investigate the threats or supports to students' self-efficacy, we are using a mixed methods approach. This novel design creates a holistic narrative of which curricular and/or co-curricular activities are impacting a student's self-efficacy as well as how and why these activities may be affecting their self-efficacy. We use a mixed methods approach to collect in-the-moment information about lived experiences. Quantitatively, we employ the Experience Sampling Method (ESM) using surveys of domain-specific self-efficacy. Qualitatively, we use daily reflections to investigate threats and supports toward students' self-efficacy. Using an example, we will present the research design while focusing on building this conversation between the ESM and qualitative reflections.

PS.A-SA-7.05: Student Engagement with Modeling in Multiweek Open-Ended Lab Projects

Contributed – Victoria Borish, University of Colorado Boulder

Jessica R. Hoehn, Heather J Lewandowski, University of Colorado Boulder

Modeling is an important skill in experimental physis and thus a learning outcome of many laboratory classes. One promising approach to encourage modeling is to incorporate multiweek open-ended projects within lab courses. However, not much work has been done on assessing student engagement with modeling in actual courses. We present an analysis of projects from three upper-level university lab courses at different institutions where we investigate how the students engage with modeling and how this engagement differs depending on features of the projects. The projects in our dataset vary widely with different degrees of model construction. We observe correlations between features of the projects and the ways the students engage with modeling, which may have implications for how instructors guide students towards choosing certain types of projects.

PS.A-SA-7.06: Investigating Impact of Transfer Credits on Time-to-Degree Using Regression Models

Contributed – Alyssa Waterson, Michigan State University

Marcos D. Caballero, Rachel Henderson, Michigan State University

Earning a bachelor's degree is expensive and time-consuming. Many undergraduate students pursue Advanced Placement (AP) courses in high school or transfer coursework from other degree-granting institutions. However, the effect of those transfer courses on the time it takes students to graduate (time-to-degree) is currently not well understood. In this work, we investigated how incoming transfer courses impact students' time-to-degree. To do so, we explored how well a logistic regression model would predict whether a student graduated before or after 8 semesters, 10 semesters, and 12 semesters. When discerning time-to-degree, there are several other features that were also considered in addition to transfer status: students' demographic information such as race/ethnicity, gender, first-generation status, and their academic background preparation as measured by their high school GPA and math placement scores. Here, we will discuss the findings of our model as well as the effects of data imputation on our results.

PS.A-SA-7.07: Narrative Analysis of Two-Year College Transfer Student's Experiences

Contributed – Laura Wood, Michigan State University

Vashti Sawtelle, Michigan State University

Two-year college (TYC) transfer students' experiences are understudied. We know these students can face unique challenges after transferring and can miss some of the positive aspects of their TYCs at their receiving institutions. We use narrative analysis to tell the story of one transfer student from a TYC to a four-year college (FYC) named "Nicole". Nicole has social anxiety, but thrived in her relationships with peers and professors while at her TYC. Then she faced difficulties finding study groups, community, and a sense of belonging at her receiving institution. Pulling from a variety of data sources, including observational field notes, written journal reflections, and semi-structured interviews, we will describe the shifting role of supporting characters in Nicole's story and the aspects of the settings that contributed to Nicole's differing experiences at the two institutions.

Session: PS.A-SA-8 PER: Diverse Investigations III **Saturday, July 31, 12:30–1:45 p.m.**
Sponsor: Committee on Research in Physics Education **Presider:** *TBA*

PS.A-SA-8.01: Communication Apprehension and Learning Profiles in Introductory Physics

Contributed – Craig Wiegert, University of Georgia
Heather B Hewitt, University of Georgia
Jarrad W.T. Pond, Aurora Community College

We investigated the relationships between communication anxiety and learning profiles in students from introductory physics and physical science courses. Participants in courses from several semesters completed two surveys, the Personal Report of Communication Apprehension (Richmond and McCroskey 1985; Williams 2001) and the Student Characteristics Survey (Pond 2016). Students with a high level of communication apprehension are much less likely to practice self-regulation, participate in collaborative learning, or engage in both high and low-level question asking. They also tend to take a surface-level approach to learning, and engage in task avoidance more than students with low scores for communication anxiety. Students surveyed in courses that were taught in a hybrid or online format, as a result of the COVID-19 pandemic, reported significantly higher levels of communication anxiety; given the correlation between communication apprehension and less effective learning strategies, this has implications for the quality of physics learning during the pandemic.

PS.A-SA-8.02: Preparing Students for Impactful Careers through Context-Rich Physics Learning

Contributed – Anne Leak, High Point University
Jessica-Rose Greene, High Point University
Benjamin M Zwickl, Rochester Institute of Technology

Physics majors need context to improve their experiences with physics as a discipline and prepare them for a variety of impactful careers. Yet, the majority of context-based physics learning comes from internships and research experiences that are not always available to all students. As part of the APS PIPELINE Network and Physics for Tomorrow initiatives, we examined students' experiences with context-rich physics through internships, co-ops, and undergraduate research. We compared these with students' perception of physics as it relates to their future career goals and career-relevant skills. Responses from 149 physics majors at 12 institutions were analyzed using descriptive quantitative methods for multiple select questions and emergent thematic qualitative approaches for open-ended questions. We offer considerations for the importance of context-rich physics experiences, as well as how to integrate these into lecture and lab coursework, so that context-based learning can become more accessible to all physics majors.

PS.A-SA-8.04: Research on Identity Development Among Physics Transfer Students

Contributed – Frank Dachille, San José State University
Gina Quan, San José State University

In this talk, we qualitatively analyze physics majors' identity development as they transfer from a community college to a four-year university. Students in the study attend a large, public four-year university in which a significant fraction of undergraduate physics majors are transfer students. Research participants had previously enrolled in a required 1-credit introduction to the physics major course designed to cultivate community and identity, as well as foster a broad set of physics-related skills. In one-on-one interviews, students discussed their academic and personal experiences before, during, and after their transition from community college to a four-year university. In this talk, we will discuss how their academic and personal experiences as well as their interactions with physics community members shaped their identity development as physics students. We then consider implications for building institutional supports for physics transfer students.

PS.A-SA-8.05: Unpacking Tensions in a Pedagogical Transition from Lectures to Modelling

Contributed – KK Mashood, Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India.*
Tripti Bameta, Nirpan Securities Pvt. Ltd., Mumbai, India.
Ayush Gupta, Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India.

We analyze a session where high school students in a 2-day science camp were asked to explain the workings of a mercury barometer. The session was designed to provide students with opportunities to participate in the knowledge construction process. The pedagogy was inspired by literature on modelling practices and sense making in physics. Given that traditional classrooms in India (and elsewhere) are often dominated by the lecture format, it is important to investigate the tensions that arise when the students from a traditional physics classroom are asked to engage with modeling and sense-making. We analyzed the video recording of the session to unpack these tensions and characterized them under four broad categories vis-a-vis: Instructor versus student agency; Answer-making versus sense-making; Qualitative reasoning versus mathematization; and Substance versus process ontology. Our analysis shows how the flow of conversation was guided by the push and pull of these tensions.
*Sponsor: Ayush Gupta

PS.A-SA-8.06: Unpacking Assumptions in Students' Reasoning about Socio-Technical Issues

Contributed – Ayush Gupta, Homi Bhabha Center for Science Education, Tata Institute of Fundamental Research, Mumbai, India
Chandra Turpen, Andrew Elby, University of Maryland, College Park
Thomas M Philip, University of California, Berkeley

Many physics and engineering students, in their future professions, will work on science and technology projects that are influenced by social, political, and economic contexts while also impacting these same conditions. This includes military technology. As such, students need to develop an understanding of the ethics of use and development of these technologies, make sense of the potential for harm, and become aware of the tacit assumptions they make when reasoning about these issues.
In this talk, we will present our analysis of the assumptions undergirding a short segment of talk from a classroom discussion on the ethics of the use of weaponized autonomous drones by the US military in Yemen and Afghanistan. Our analysis outlines the science/engineering disciplinary practices that structure the argument and the qualities of the underlying assumptions, with implications for design of learning environments for ethical STEM education. (Funding: NSF SES #1338700 and NSF SES #1338753)

Session: PS.A-SA-9 PER: Student Content Understanding, Problem-Solving and Reasoning I

Saturday, July 31, 12:30–1:45 p.m Sponsor: Committee on Research in Physics Education Presider: *AJ Richards*

PS.A-SA-9.01: Impact of Mathematical Rigor on Students' Understanding of Quantum Optics

Contributed – Paul Justice, University of Cincinatti

Emily Marshman, Chandralekha Singh, University of Pittsburgh

In this study, we consider a Quantum Interactive Learning Tutorial (QuILT) which incorporates mathematical rigor while focusing on helping students develop a good conceptual understanding of quantum optics using a Mach Zehnder Interferometer with single photons and polarizers. We compare the performance on conceptual questions of upper-level undergraduate and graduate students who engaged with this "hybrid" (integrated conceptual and quantitative) QuILT with those who engaged with a conceptual QuILT focusing on the same topics without quantitative tools. Both versions of the QuILT use a guided inquiry-based approach to learning and are based on research on student difficulties in learning these challenging concepts as well as a cognitive task analysis from an expert perspective. 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.

PS.A-SA-9.02: Evolution in Student Conceptual Understanding of Electricity and Magnetism

Contributed – Mary Jane Brundage, University of Pittsburgh

Chandralekha Singh, University of Pittsburgh

The Conceptual Survey of Electricity and Magnetism (CSEM) is a multiple-choice survey that contains a variety of electricity and magnetism concepts at the level of introductory physics used to help inform instructors of student mastery of those topics. Prior studies suggest that many concepts on the survey are challenging for introductory 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 CSEM questions in order to understand the evolution of student understanding of these concepts from introductory to upper-level to graduate level. We analyze the CSEM questions that remain challenging for upper-level and graduate students.

PS.A-SA-9.03: Rubrics to Teach Problem-Solving Strategies in Large Enrollment Online Courses

Contributed – Joshua Rutberg, Rutgers University - Newark

Eugenia Etkina, Rutgers University Graduate School of Education

The solving of physics problems is often an important component of introductory physics courses. For many students, approaching a physics problem, organizing their thoughts, and reaching a solution is a novel skill which needs to be taught and mastered. Rubrics can be powerful tools to guide student development of new skills. Here we will discuss the development of problem solving rubric we have implemented in our large enrollment introductory physics course. We will discuss the particular challenges and advantages of using these rubrics in an online course. Finally, we will then discuss the extent to which these rubrics were successful in changing student behavior over the course of two semesters of instruction.

PS.A-SA-9.04: Seeking Coherence and Switching Reasoning after Forgetting an Equation

Contributed – Katherine Gifford, Adelphi University

Gabriel S. Ehrlich, Eric Kuo, University of Illinois at Urbana-Champaign

Engin Bumbacher, Haute École Pédagogique Vaud

Selection and application of an appropriate equation is a key step in instructional problem-solving strategies. But what if one cannot exactly recall the relevant equation? We are currently investigating how coherence between physical and mathematical reasoning opens multiple solution pathways for qualitative physics problems. In one-on-one interviews, community college students, 4-year college undergraduates, and graduate students solved qualitative introductory-level E&M questions. Analysis of 18 interviews showed that while many students had initial difficulty in recalling a relevant equation, they demonstrated strategies for making progress. One interviewee was unsure whether the time constant for an RC circuit is RC or 1/(RC) and sought coherence with qualitative reasoning to determine the correct expression. Another student switched to reasoning qualitatively from a physical model after noting that they could not recall a relevant equation. These examples show how mathematical and physical reasoning is opportunistically incorporated in students' problem solving.

PS.A-SA-9.05: Resolving Inconsistencies in E&M by Seeking Coherence Between Physical/Mathematical Reasoning

Contributed – Gabriel Ehrlich, University of Illinois at Urbana-Champaign

Katherine Gifford, Adelphi University Eric Kuo, University of Illinois at Urbana-Champaign Engin Bumbacher, Haute École Pédagogique Vaud

Qualitative physics problems can often be solved through physics concepts, reducing the need for equations. However, mathematical reasoning can still be useful or even necessary to solve such problems. How do students combine physical and mathematical problem solving resources into coherent lines of reasoning? In this talk, we report on an analysis of 18 interviews with students solving qualitative E&M problems. We find that students frequently encounter an inconsistency while working on one line of reasoning, such as deriving an equation that contradicts their intuition, and in response recruit another type of reasoning, such as by developing an analogy to a related physical system to understand their equation. By seeking coherence between their multiple lines of reasoning, students can identify their mistakes and resolve inconsistencies. We will show case study excerpts to illustrate our results.

PS.A-SA-9.06: Student Difficulties Identifying Diagonal Operators for Degenerate Perturbation Theory

Contributed – Christof Keebaugh, Franklin & Marshall College

Emily Marshman, Community College of Allegheny County

Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with the representation in which a Hermitian operator cor- responding to a physical observable (e.g., the Hamiltonian operator corresponding to energy) is diagonal in the context of degenerate perturbation theory involving the Zeeman effect in the hydrogen atom. This investigation was carried out in advanced quantum mechanics courses by administering written free-response and multiple- choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts, knowledge of which can be useful for developing research-validated learning tools.

PS.A-SA-9.07: Evaluating Student Ability to Draw Conclusions from Measurement Data

Contributed – Tong Wan, Westminster College

Joshua Mickelsen, Westminster College

In this study, we surveyed students from a calculus-based and an algebra-based introductory physics courses at a liberal arts college about their ability to draw conclusions from measurement data. Both courses are taught in studio mode and use the Workshop Physics curriculum. The survey was administered online before and after instruction on measurement uncertainty. In the survey, students considered two experiments that differ only by one setup. Students were first asked to make predictions about the experimental outcomes as to whether or not the outcomes agree with each other, and then were given data to analyze and draw conclusions. We evaluate the extent to which instruction impacts student ability to draw conclusions as well as reasoning about measurement uncertainty. We use the framework of point and set paradigms to characterize student reasoning. The set paradigm emphasizes a measurement distribution rather than a single measurement; it is considered more expert-like.

PS.A-SA-9.08: Pedagogical Implications of Synthesis Problem Solving

Contributed – Bashirah Ibrahim, Bahrain Teachers College, University of Bahrain   Lin Ding, Department of Teaching and Learning, The Ohio State University

In study of synthesis problem solving, we distinguished two types of synthesis tasks: sequential and simultaneous. To capture their distinctive characteristics and differing impacts on problem solvers' sensemaking behaviors, we investigated students' gaze transitions between problem text and diagram as well as between different components within a diagram. Our work is underpinned by the cognitive theory of multi-media learning; that is, greater gaze transitions indicate greater mental effort in information integration. We found that when multiple events were integrated sequentially, students made great cognitive effort to connect information within a diagram. When events occurred simultaneously, students' mental efforts focused mainly on linking text and diagram. Regardless, in both cases students sought to connect information for comprehending the problem situation, which is a core of effective problem solving and deep learning. We maintain that synthesis tasks can support student development of expert-like habits of mind.

PS.A-SA-9.09: Instructional Implications of Findings on Students' Mathematics Difficulties*

Contributed – David Meltzer, Arizona State University

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

We have administered diagnostic tests covering pre-college mathematics to over 6700 introductory physics students at four state universities, with largely consistent results. Key findings include: (1) Use of symbols to replace numbers in otherwise identical algebraic equations significantly lowered correct-response rates, implying that instructors may want to be more cautious when employing symbolic manipulations; (2) Few physics students solved algebraic equations by "isolating the unknown variable," implying that instructors' standard and habitual approach to algebraic manipulation may appear confusing, and should be modified or better scaffolded; (3) Class-average scores on even a single diagnostic test item were highly predictive of average scores on other items covering varied topics, suggesting it may be possible to diagnose the level of students' difficulties with very few pretest items; (4) During interviews, students tended to self-correct approximately 60% of their initial errors, suggesting that instruction on self-checking strategies may offer disproportionately high returns.

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

PS.A-SA-9.10: Symbolic Manipulation Fluency Predicts Introductory Physics Students' Mathematical Preparedness*

Contributed – Dakota King, National Heart, Lung, and Blood Institute, National Institutes of Health

David E Meltzer, Arizona State University

Whether it is rearranging a kinematics equation or applying Newton's second law, introductory physics students are often asked to solve problems that require the manipulation of symbols. After analyzing nearly 7,000 mathematics diagnostics administered at four large state universities, we find that many introductory physics students struggle with basic algebra to a degree that could impact their course performance. Correct-response rates on algebra problems drop significantly when numeric coefficients are replaced with symbols. Even the replacement of one type of symbol (Latin letters) with a less-familiar type (Greek letters) seems to have a significant negative effect on performance. We also find that performance on symbolic-type algebra problems is highly correlated with performance on trigonometry, geometry, and graphing problems. We will report our analysis of these results while providing an overview of our recent findings.

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

Session: PS.A-SA-11 Elements of an Integrated Curriculum

Saturday, July 31, 12:30–1:45 p.m Sponsors: Committee on Educational Technologies, Committee on Physics in Undergraduate Education Presiders: *Kelly Roos, Crystal Bailey*

PS.A-SA-11.01: Fostering Synergy Among Mindset and Skillset

Invited – Bahram Roughani, Loyola University Maryland

Physics education is facing challenges in terms of ensuring student engagement with physics. This can be due to the techno-centric approach in physics education when little or no attention is devoted to exploring the relationship between physics concepts and human needs. To change this may require that in addition to examining questions of "what" and "how" required for developing skills in abstract problem-solving, we may also need to leverage a techno-centric approach to teaching physics curriculum to enhance student engagement with physics by helping them to understand the "why" that inspires STEM undergraduates to learn physics. The essence of the socio-technical approach to physics education is based on contextualizing physics in real-world applications that reveals impact of physics on human and humanity. We will discuss the results the connection between Physics Innovation and Entrepreneurship computational and laboratory skillset that can offer an enhanced model for teaching physics.

PS.A-SA-11.02: Integrating Computation, Experimentation, Projects, and Human-centered Applications in Lab Courses

Invited – Benjamin Zwickl, Rochester Institute of Technology

Lab courses can meet the ideals of a "Physics for Tomorrow" curriculum by integrating theory, computation, and experimentation in ways that emphasize social impact and career-relevant applications. COVID-19 served as the catalyst for a significant overhaul of the 2nd-year electronics lab at Rochester Institute of Technology, which is taken by about 45 physics majors. The course now uses low-cost lab kits (120 USD), which increase the hands-on lab experience for every student, whether they are in-person or remote. Circuit simulations in LTspice (free) provide experience with commercial circuit simulators, while Jupyter notebooks are used as electronic lab notebooks and to incorporate scientific Python. An optical heart rate monitor is the focus of a culminating 2-week lab showing human-centered interdisciplinary applications of physics and electronics. Finally, multi-week final projects are proposed and executed by students to reinforce that physics is a creative and applied discipline.

PS.A-SA-11.03: Updating the Curriculum with Social Context and Practical Application

Invited – Walter Freeman

Introductory physics classes often present physics in an overly-abstracted context that is far removed from how it is actually practiced, and the impact that it has on society. In this talk, I will advocate for teaching physics in its broader context as a driver of social change and economic agency. Additionally, I will argue that classroom physics should more closely resemble the real-world practice of physics, with an emphasis on computational methods and the analysis of empirical data instead of just analytical derivations. These approaches both increase recruitment and retention, by presenting physics as an inspiring vehicle for change and a practically-useful set of skills, and better prepare students for the careers that they are likely to have when they graduate.

Session: PS.B-SA-1 Best Practices for Developing Scientific Thinking, Reasoning, and Decision-Making Abilities II

Saturday, July 31, 2–3:15 p.m. Sponsor: AAPT Presider: *Krista Wood*

PS.B-SA-1.01: Using Deliberative Democracy to Develop Scientific Skills through Group Collaboration

Contributed – C. Croft, Portland State University

P. Jamkhedkar, R. Widenhorn, Portland State University

In order to prepare students as future professionals, reforming science, technology, engineering, and mathematics (STEM) education has been demanded by education committees and government bodies alike. To become successful and effective scientists, medical professionals, or engineers, students must be skilled in science application, peer collaboration, science-based critical thinking, and effective communication. As misinformation spreads quickly and resistance to scientific knowledge thrives, the future of science depends on preparing students to overcome this opposition. In order to foster these skills, we used the Deliberative Democracy (DD) active-learning model. Each module focuses on a socially relevant and sometimes controversial scientific problem (e.g. climate change), tasking students to collaborate with their peers to identify the scientific issues, building physics models, researching & deliberating solutions through policies and regulations, and effectively communicating these in a written report. We will walk through the development process and share early results from this project in this talk.

PS.B-SA-1.02: Supporting Metacognition in Physics Problem Solving

Contributed – Elien Sijmkens, KU Leuven*

Mieke De Cock, KU Leuven

Tinne De Laet, KU Leuven

Problem solving is an important aspect of physics education. To become skilled problem solvers students do not only need sufficient conceptual and procedural knowledge, they also need metacognitive skills in order to monitor their solution process. We present a prototype for an online tool that aims at stimulating students' metacognitive skills for problem solving by offering them problem-specific reflection questions. We discuss a case study of the implementation of the tool within a 1st year mechanics course and connect students' interaction with the tool to their metacognitive skills.

*Sponsor: Mieke De Cock

PS.B-SA-1.03: Developing Critical Thinking Skills through Laboratory Experiences

Contributed – Nancy Ruzycki, University of Florida

The Department of Materials Science and Engineering at the University of Florida, has specifically designed student laboratory experiences to scaffold and support student critical thinking and build key core conceptual models for students in materials including; heat flow and response to heat energy in materials, material structure, property and performance relationships, phase transformations in materials, and structure, bonding and electronic properties in materials. Many of the key materials concepts align with physics concepts, and the design of the laboratories is appropriate for physics programs looking for application physics concepts to real world application and problem solving. These laboratory experiences include both experimental and computational activities. This talk will present the design of the laboratory modules along with staging and scaffolding of the experiences to build critical thinking, reasoning and decision making in students.

PS.B-SA-1.04: Scientific Thinking and Exploratory Discussion Posts

Contributed – Anthony Smith, Green River Community College

Discussion posts have been used to involve students in a greater understanding of class material, particularly in applying it to the world outside the classroom. For online classes, they often serve as the primary channel through which students communicate with each other. We can also use discussion posts to facilitate scientific thinking and analysis by having students explore a question or problem, research it to find sources, and interpret results. These range from watching an educational video and describing the host's analysis and results for a particular experiment, to doing their own search on everyday phenomena like static electricity in laundry, power generation on a Washington wind farm, or lightning. These types of weekly discussion posts have been added to both my Introductory Physics and Astronomy classes, and student engagement and reaction has been overwhelmingly positive.

PS.B-SA-1.05: Developing Skills for Validity Checking of Intuitively Appealing Responses*

Contributed – Safana Ismael, North Dakota State University

After instruction, many students apply basic physics knowledge correctly to solve problems that require straightforward applications of that knowledge. At the same time, some students struggle to apply the same knowledge in situations that elicit alternative intuitive ideas. To recognize an inconsistency between such intuitive ideas and formal knowledge, a process of conflict detection and override must be initiated. However, for this process to be sustained, students must articulate criteria that must be satisfied to accept or reject an intuitive response. It appears that many students need explicit instruction to help them recognize that the same physics knowledge could be used 1) as a tool for solving a given problem and 2) as a criterion for checking for the validity of intuitive responses. We will describe our efforts to design instruction in an introductory calculus-based Mechanics course that focuses on the second aspect of physics knowledge.

*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

PS.B-SA-1.06: Assumptions and the Relative Value of Evidence in Lab

Contributed – Christopher Moore, University of Nebraska Omaha

Good science thinking incorporates an evaluation of assumptions and the relative value of evidence. A good scientist makes judgments using experimental results while simultaneously maintaining a sense of skepticism in their judgments based on how much they think they know something. This variable confidence requires strong metacognitive faculties. In this talk, we will discuss a series of lab activities on motion and force where students explicitly evaluate their assumptions and the evidence before them. The activities were designed using the Investigative Science Learning Environment (ISLE) framework and metacognitive "thinking tasks" from the book Teaching Science Thinking. Specifically, students design an experiment that answers the following research question: "is the magnitude of the acceleration of a cart rolling up an incline the same as when it rolls back down?" This simple question and the surprising empirical results lead to a multiple week exploration where assumptions and uncertainty are made explicit.

PS.B-SA-1.07: Comparing In-person and Online Physics Labs for Developing Scientific Reasoning*

Invited – Kathleen Koenig, University of Cincinnati

Lei Bao, The Ohio State University

The ability to effectively engage in evidence-based decision-making is an important educational outcome. Over the past decade, we have developed and evaluated a lab curriculum in which all activities are designed around the theory-evidence coordination framework to advance select reasoning skills. For each lab, students address a central research question, and guided activities explicitly emphasize causal and hypothetical reasoning embedded in cycles of inquiry, reflection, evaluation, and communication of outcomes. Due to the pandemic, the labs were redesigned for online synchronous delivery where students worked in groups of four in Zoom breakout rooms. The presentation will showcase the underlying reasoning framework that can be used by others to develop their own materials, discuss how students were still able to collect data and create mathematical models in the online format, and compare learning outcome data for both the online and face-to-face settings. Access to the lab materials will also be provided.

*Partially supported by the NSF IUSE 1431908

Session: PS.B-SA-2 Doing Physics and Being ______ **Saturday, July 31, 2–3:15 p.m.**

Sponsor: Committee on Diversity in Physics, Committee on Physics in Two-Year Colleges **Presider:** *Carolina Alvarado*

PS.B-SA-2.01: Doing Physics and Being #NotYourModelMinority

Invited – David Marasco, Foothill College

As an Asian-hertiage person in higher education, I've been confronted with the model minority myth for most of my life. While reflecting upon this, I will share my immigration story, my family's history in America, my relative privilege, and how all of these shaped who I am. I will discuss some of the physics activities I have engaged in outside of the classroom. Additionally, as faculty at two year colleges often wear many hats, I'll talk about some of the non-physics roles I play as a person of color in my institution's ecosystem.

PS.B-SA-2.02: Doing Physics and Being Chicana and Indigena

Invited – Ximena Cid, California State University, Dominguez Hills

In this talk, I will share lived experiences of being bicultural (Chicana and Yaqui) as well as how I've developed my identity as a physicist. Additionally I will share how my identities have supported the work that I do in the field of Physics Education Research.

PS.B-SA-2.03: Doing Physics and Being Unsure of How to Introduce Myself

Invited – Debbie Andres, Paramus High School

It wasn't until I left my home town that I realized I wasn't sure how to introduce myself. As a daughter of immigrants and coming from a mostly hispanic community, my last name only had one pronunciation. I left my hometown for high school and it was here I began to wonder: should I use the real pronunciation of my last name or should I just make it easier for everyone else? This question has followed me throughout my professional years as a teacher. Last year I began to question my choice on choosing the "easy" route. I am usually one of the few Latinas in a conversation and I didn't want to "stand out" with a different sounding name. But my name carries my family's sacrifices and struggles. I will share my journey on how I've reached this resolve and how I want to re-introduce myself to the community.

PS.B-SA-2.04: Teaching Through Cognitive Fog: How being Disabled Transformed My Life

Invited – Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Halfway through my senior year in physics, in the middle of my REU experience, my life changed. I was diagnosed with Multiple Sclerosis, an auto-immune disease where the body's own immune system attacks the myelin sheaths around its nerves. In the twenty-eight years since, I have had to deal with many issues related to being a disabled physics student, a disabled physics and astronomy graduate student, a disabled director of instructional support and a disabled physics/ astronomy professor. I spent the first 15 years after being diagnosed, terrified of being judged. I became ashamed and secretive about my condition, even though students and colleagues knew something was wrong. In this talk, I will share some of the key transformative stories that have led me to where I am today and how I finally overcame the shame to become an advocate for disabled scientists.

Session: PS.B-SA-3 Examining Student-side Interactions with Technology **Saturday, July 31, 2–3:15 p.m.**

Sponsor: Committee on Educational Technologies **Presider:** *Katie Ansell*

PS.B-SA-3.01: Assessing the Efficacy of Technological Tools to Teach Electric Fields

Contributed – Liana Rodelli, Ithaca College

Colleen L Countryman, Ithaca College

It can be difficult for introductory physics students to understand the nature of electric fields because electric fields are not tangible nor visible. With the intent of providing students the tools to help them understand electric fields, we conducted a study, via Zoom, in which we tested the efficacy of three technological learning tools in developing student understanding of electric fields. The tools, developed by our team, include a video lesson, an electric field simulator, and an online electric field game. The students in two sections of a second-semester, algebra-based physics course were each randomly assigned to use one of the three tools. All completed pre- and post-activity diagnostics including questions targeting the learning objectives, beliefs about physics, and learning preferences. We will discuss the results of our study and the implications on the development of future tools.

PS.B-SA-3.02: Developing Entrepreneurial Mindset through iOLab-based Activities in Introductory Physics Courses

Contributed – Daniel Marincel, Rose-Hulman Institute of Technology

Maarij Syed, Kosta Popovic, Rose-Hulman Institute of Technology

The introductory physics sequence at Rose-Hulman Institute of Technology develops a common knowledge base for 500+ freshman students, with all majors required to complete the first two courses. In pursuit of enhancing our courses with active learning in a hybrid environment due to COVID-19 restrictions, we implemented iOLab-based exercises during the Winter and Spring quarters of the 2020/2021 academic year. The open-ended activities were designed to pique students' intrinsic curiosity and help students develop more connections between theory and "how things work" through demos and experimental design. Students also identified opportunities to create value by exploring applications of sensors in the world around them. These skills directly relate to the students' entrepreneurial mindset, which was assessed by a pre- and post-ESEMA survey. We also sought to understand the effectiveness and student perception of the iOLab in a hybrid setting through their written comments and attitudes from a post-StRIP survey.

PS.B-SA-3.03: Augmented Reality as Assistive Tool for Electricity Lab Courses

Contributed – Michael Thees, Technische Universität Kaiserslautern, Physics Education Research Group

Sebastian Kapp, Fabian Beil, Technische Universität Kaiserslautern, Physics Education Research Group

Kristin Altmeyer, Sarah Malone, Saarland University, Department of Education

Regarding science lab courses, Augmented Reality (AR) allows for adding virtual representations of various types into the real environment to visualize physical quantities; e.g., when examining electric circuits, real-time visualizations of measurement data can be anchored to corresponding experimental components. In this way AR addresses design principles from multimedia learning theories like spatial and temporal contiguity while preserving traditional interactions with the experiment. We present theoretical foundations and detailed empirical results from three studies investigating the effects of using AR on conceptual knowledge acquisition and cognitive load. There, learners had to explore fundamental laws of DC circuits based on observed data. The AR-based presentation format is compared with a tablet-based non-AR condition, where the same representations were visualized as a data matrix. While both conditions led to high learning gains during a graded lab course, reducing extraneous load depends on which presentation format fits the demands of the learning tasks.

PS.B-SA-3.04: Gamification of Electric Fields to Improve Students' Understanding and Engagement

Contributed – Ted Mburu, Ithaca College

Because electric fields cannot be touched or seen, simulations are often utilized to build students' understanding of them by providing them with a visual representation of electric fields and the motion of test charges through them. We developed a game to address these challenges. The goal of the game is to guide a test charge through a racetrack using an electric field that the player creates. As a student plays the game, they will see dynamic electric field lines created by the charges they place on the screen, as well as the trajectory of test charges through the electric field. Our aim in the gamification of a more traditional electric field simulation is to improve motivation and engagement in the material. Both the game and the simulation that we built before it are built in JavaScript, so they will run on most browsers on a computer or mobile device.

PS.B-SA-3.05: Resources in Introductory Physics: Multiple Modes of Engagement and Feedback

Contributed – Charles Ruggieri, Rutgers, The State University of New Jersey

In this study of a large enrollment introductory physics course, I investigated students' use of free online resources (YouTube, Khan Academy, Chegg) and newly-implemented course resources since the Covid-19 transition to remote learning. Using a mixed-methods approach, I surveyed and interviewed students on their perceptions and use of expanded course resources which include pre-lecture module with: learning objectives, introductory videos, quizzes with instructional feedback, tutorial assignment with low-stakes grading parameters, and demonstration videos. Students also engage with weekly activities similar to pre-Covid-19 but adapted to the remote setting, including synchronous remote lectures and active-learning recitations, asynchronous recitation quizzes as exam-like practice, and online homework assignments. The survey data suggest students valued the expanded course resources as helpful to their learning, and reported little use of solutions sites like Chegg. Despite increased accessibility of virtual meetings, students still did not engage frequently with course office hours or the University Learning Centers.

PS.B-SA-3.06: A Data Driven Study of Students' Completion of Online Homework

Contributed – Zhongzhou Chen, University of Central Florida Physics Department

Academic integrity in online learning environments is a prominent concern for many instructors, especially during the recent pandemic driven remote instruction period. In this study, we present method to identify students' answer copying behavior by analyzing the time between problem access and answer submission, plus the correct rate on each problem. In an end of course survey, 42 students self-identified as having completed all of the homework problems themselves. We contrast both the distribution of submission time and interaction pattern of those students with the rest of the student population, and identify patterns in students' data that could indicate copying or other abnormal problem solving behavior. We then use those data indicators to estimate the prevalence of answer copying, as well as identify students who engage in copying behavior more frequently than others.

PS.B-SA-3.07: A Free, OER, PER-based, PER-focused Curriculum for Introductory Physics

Contributed – Evan Thatcher, Oregon State University

KC Walsh, Oregon State University

Ryan Scheirer, Oregon State University Cascades

This talk will introduce a modern Open Education Resources (OER) flipped classroom curriculum developed for an introductory algebra-based physics sequence. These resources were created by the Project BoxSand PER group at Oregon State University with support from OSU's Ecampus. This curriculum is unique in its ground up design from hundreds of fine grain learning objectives, powerful built in research framework to which resources are coded, and suitability for both in person and remote delivery. The development process, curriculum examples, and how to access the resources (including direct LMS integration) will be presented. The currently available OER includes pre-lecture, lecture, and post-lecture activities. A laboratory curriculum with modern learning objectives, designed with remote learning in mind, will soon be available. OSU has partnered with Vernier to provide the OER lab manual with physical lab kits for rent or purchase. Other resources, including a sizeable question database will be available soon.

PS.B-SA-3.08: Building Social Networking and Communities in Remote Physics Laboratories

Contributed – Drew Rosen, Stony Brook University

Angela M Kelly, Stony Brook University

Social learning is a central aspect of physics laboratory practices. However, not all situations allow for students to work in close, physical proximity together such as in remote learning environments. In particular, asynchronous courses may inhibit a student's ability to form strong, meaningful connections with classmates and instructors, suppressing the formation of social networks and communities of practice. This can reduce students' motivational factors such as self-efficacy, which has previously been linked to performance and/or a desire to persist. This study examines how an instructor-initiated social learning environment utilizing the online discussion platform Slack may affect students' social learning activities and self-efficacy. A pre-/post-survey design was utilized to compare in-person and remote students' social learning activities and self-efficacy in the Spring 2021 semester. The logistical aspects of implementing and maintaining a Slack group as well as the survey findings are presented, along with implications for policy and practice.

PS.B-SA-3.09: Science of Learning with Technology Using Multimodal Self-Regulated Learning Data

Contributed – Roger Azevedo, University of Central Florida

Understanding learners' use of cognitive, affective, metacognitive, and motivational self-regulatory processes is foundational to a science of learning. Interdisciplinary researchers have recently used learning technologies (e.g., virtual reality) to enhance learning by inducing, fostering, and supporting self-regulatory processes while using advanced learning technologies. Despite emerging research, much work is still needed given the various theoretical models and assumptions underlying human learning, methodological approaches (e.g., log-files, eye-tracking), and analytical methods. In this presentation, I will focus on several major challenges currently facing researchers, educators, and learners, including: (1) theoretical and methodological challenges related to real-time detection, tracking, and modeling of self-regulatory processes; (2) recent work on using multimodal data to detect, track, and model self-regulatory processes while learning with learning technologies; and, (3) outlining opportunities that have the potential to significantly enhance learning by providing real-time, intelligent support of learning, problem solving, and reasoning across domains.

Session: PS.B-SA-4 Get the Facts Out: Changing the Conversation Around Physics Teacher Recruitment Saturday, July 31, 2–3:15 p.m. Sponsors: Committee on Physics in High Schools, Committee on Teacher Preparation Presider: *Drew Isola*

PS.B-SA-4.01: Video Solution to GFO for Asynchronous Community Colleges Courses

Contributed – Jeffrey Williams, Bridgewater State University

Allison Daubert, Bridgewater State University

With the support of a PhysTEC Recruitment Grant, Bridgewater State University (BSU) is working with two of our feeder community colleges to provide Get the Facts Out (GFO) and early teaching experiences. Due to the pandemic our community college partners are 100% online and asynchronous. The asynchronous aspect makes it very difficult to reach the students, so we re-invent how to present GFO to the introductory physics classes. Our solution was to develop video homework problems that embedded parts of our GFO presentation. BSU's TIR Allison Daubert developed the videos which feature students in the BSU's Physics Education Group. The video homework problems are in a central youtube channel allowing for easy assignment by the community college professors. The community college professors assign the video homework as a graded part of the course assuring all the students view the videos.

PS.B-SA-4.02: GFO implementation at an Aeronautical University

Contributed – Richard Pearson III, Embry-Riddle Aeronautical University

Changing the conversation around the grade 7-12 teaching profession is at the core of the "Get the Facts Out" (GFO) campaign. To do so at institutions without explicit aim to recruit or train secondary teachers displays the potential reach of GFO itself. An example institution fitting that description is Embry-Riddle Aeronautical University (ERAU): a private, aeronautical, engineering-focused university. Though strides are being made at ERAU to highlight pathways to secondary teaching, much potential remains in changing the conversation. This presentation will provide an expanded update to previous data collected, plans for spreading GFO-related materials, and pressing obstacles.

PS.B-SA-4.03: Why Physics Professors Should Take Undergads to an AAPT Meeting!

Contributed – Remi Kauderer, Vassar College

Rafi Ettinger-Finley, Béla Arwen, Vassar College

The goal of this paper is to explain why physics professors should bring their undergraduate students to an AAPT meeting. This paper will include interviews from students who have gone to an AAPT meeting, analysis on what they got out of the meeting and will propose methods to get the word out about these meetings. After hearing from students who have gone to a meeting, we have found that students had very good experiences and they obtained exposure to more applied physics in the professional world. Hopefully, this paper will demonstrate the benefits that undergrads gained after going to an AAPT meeting and also convince other professors to take their students as well.

PS.B-SA-4.04: Factor Analysis of the PTaP.HE

Contributed – Jared Breakall, Colorado School of Mines

Savannah L Logan, Colorado School of Mines

Wendy K Adams, Colorado School of Mines

As part of the Get the Facts Out project, we have developed the Perceptions of Teaching as a Profession in Higher Education better known as the PTaP.HE (P-taffy), which measures faculty's perceptions of grade 7-12 teaching as a career choice. This spring we conducted a new reduced-basis factor analysis on version 2 of the instrument and found a substantial change in category structure from version 1. Here, we will share the new categories as well as present results from our national data sample which reveals themes in faculty thinking about the grade 7-12 teaching career. These results can help guide the improvement of physics teacher recruitment in colleges nationwide. This project is supported by NSF DUE-1821710.

PS.B-SA-4.05: Development and User Testing of STEM Teacher Recruitment Videos

Contributed – Savannah Logan, Colorado School of Mines

Jared B. Breakall, Wendy K. Adams, Colorado School of Mines

We have developed six new short, professional-quality teacher recruitment videos as part of the Get the Facts Out project in an effort to correct the nation's science and math teacher shortage. We began by identifying areas where a video would fit faculty teacher recruitment needs and then studied the research on developing effective multimedia and video resources. Using this research, coupled with our research on effective practices for changing perceptions, we drafted outlines of recruitment videos that we believed would be effective in recruiting teachers and changing perceptions. We chose Circuit Media, a communications company based in Denver, to create these videos. User-testing was conducted during and after the development process using faculty and student focus groups at several US universities. We will share our unique findings on what makes an effective recruitment video and how responses vary between faculty and students. This project is supported by NSF DUE-1821710.

PS.B-SA-4.06: The Latest and Greatest from Get the Facts Out

Invited – Wendy Adams, Colorado School of Mines

Savannah L Logan, Jared B. Breakall, Colorado School of Mines

Drew Isola, American Association of Physics Teachers

The Get the Facts Out project, which is entering its fourth year of funding, has an aggressive research arm that studies the effectiveness of every resource produced by the project as well as perceptions of students and perceptions of faculty at over 50 U.S. institutions. In this presentation we will share several exciting results from the project this year including a blog article that went viral, the impact on students as a result of simply sharing the facts with colleagues, and some critical differences between the challenges within mathematics, chemistry and physics departments. Finally, we will share a couple of new resources including professional STEM teacher recruitment videos and A Teacher's Life by the Numbers. This project is supported by NSF DUE-1821710 & 1821462

Session: PS.B-SA-5 Integrating Computation During a Pandemic Saturday, July 31, 2–3:15 p.m. Sponsors: Committee on Educational Technologies, Committee on Physics in Undergraduate Education Presiders: *Ernest Behringer, Walter Freeman*

PS.B-SA-5.01: Normalizing Computations Across the Physics Curriculum

Invited – Gautam Vemuri, Indiana University Purdue University Indianapolis

Andrew Gavrin, Yogesh Joglekar, Indiana University Purdue University Indianapolis

A few years ago, the IUPUI Physics Department decided to introduce computational methods in its undergraduate curriculum to enhance student learning outcomes and engagement. The overall goal is for our graduates to consider computations as a complement to traditional analytic methods, and to develop the judgment and intuition to use a judicious mix of computational and analytic methods to investigate a problem. Since the project is in its infancy, the onset of the pandemic required some adjustments to the implementation plans. In this talk, I will describe our efforts to get buy-in from every faculty member in the department, training faculty members who were not facile with computations, implementing computations in every course, and developing an assessment instrument. I will also discuss some on-going and future work that is supported by an NSF-IUSE grant to advance the goals of the project and how the pandemic provided some unexpected silver linings.

PS.B-SA-5.02: Integrating Computation in a Remote Introductory Course

Invited – Ruth Chabay, University of North Texas

Computational modeling can provide a hands-on interactive component in a course that is otherwise entirely Zoom-based. In the introductory, calculus-based course, students can build and explore principle-based models of both hypothetical and real-world systems. They can explore the effect of varying parameters, and can construct models to help determine whether videos of physical phenomena are real or faked. However, the challenges of teaching basic computational ideas to students with no previous computational experience are also magnified in this environment. Creating pre-lab activities to teach basic concepts; ensuring that computational activities are adequately scaffolded, and convincing students to interact with each other in breakout rooms have proven central to success.

PS.B-SA-5.03: Computational Tools and Humane Instincts: Computation in a Pandemic

Invited – Michelle Kuchera, Davidson College

There is a national push to better prepare our physics students in computation. How did these efforts translate to the rapid adaptation to virtual learning in response to the pandemic? In this talk, I will outline 1) computational tools that enabled remote learning of computation in my classes and 2) modifications to how I traditionally integrate computation to address the accommodation and empathy necessary as the students navigate the uncertainty of the pandemic. I will discuss using Jupyter and JupyterHub for various courses, Gradescope for real-time code feedback, and CodeCollab for collaborative coding.

Session: PS.B-SA-6 Assessment, Grading and Feedback II Saturday, July 31, 2–3:15 p.m. Sponsor: Committee on Research in Physics Education Presider: *TBA*

PS.B-SA-6.01: What Does the Force and Motion Conceptual Evaluation Pretest Measure?

Contributed – Dona Hewagallage, West Virginia University

John C Stewart, West Virginia University

This study investigates what college-level and high-school-level variables significantly predict FMCE (Force and Motion Conceptual Evaluation) pretest scores and whether differences in these variables explain gender differences observed in FMCE pretest scores. The sample consists of students attending a large eastern land-grant university in the US who are enrolled in the introductory calculus-based mechanics class (N=1060). Variables examined include college performance, high school preparation, and non-academic variables such as sense of belonging, self-efficacy, and personality. Correlation analysis and linear regression were used to understand relations between these variables.

PS.B-SA-6.02: Practice Exams Impact on Student Exam Preparation and Performance

Contributed – Tim Stelzer, University of Illinois

Eric Kuo, Muxin Zhang, University of Illinois

Jason W Morphew, Purdue University

Practice exams with immediate feedback and video solutions are among the highest rated learning resources by students taking introductory physics at the University of Illinois. These ratings align with a research showing the positive impact of formative assessment and the testing effect. Despite this alignment, data on our students' use of practice exams suggests a majority of students are completing their first practice exam less than 24 hours before the exam, rather than spacing their practice out. During the Spring 2021 semester we introduced a “mock” proctored exam one week prior to the actual exam, in an aim to motivate earlier practice exam studying. We look at how performance on the mock exam impacted student predictions, preparation and performance on the actual midterm exam. Our results show that despite the valuable formative assessment available from the mock exam, most students did not change the timing of their practice exam use.

PS.B-SA-6.03: Computational Assessment in Introductory Physics: Codes From Qualitative Interview Analysis

Contributed – Justin Gambrell, Drexel

Adam Ikehara, Eric Brewe, Drexel University

We present a qualitative analysis of twenty-six interviews about computation in introductory mechanics courses. These interviews are part of a longer term project to develop an assessment protocol for computation in introductory physics. Interviewees were drawn from either: introductory physics, research on computation within physics, or an industrial physics career that involves computation. The interviews were coded into twenty-seven different nodes and sub-codes within each node to concentrate and differentiate between node details. We find that an assessment should not be language specific, even though Python is a favorite. The computational level at which interviewees expect students to have when they exit the course varies immensely. Some interviewees have a goal of getting students thinking about or feeling better about computational practices without performing computational practices themselves. Other interviewees have a goal of students solving many problems computationally, the capability to use multiple programming environments, and writing programs from scratch.

PS.B-SA-6.04: Using Ranking Question to Assess Students Assistants' PCK-Q*

Contributed – Weston Wegleitner, Texas Tech University

Kerina Joyles, Beth Thacker, Texas Tech University

As part of a project to develop a written instrument for assessing student assistants’ (SAs’) pedagogical content knowledge (PCK) in the context of questioning (PCK-Q), we are experimenting with questions in a ranking format. Previously, we have developed and validated questions in free-response format. We are now using those questions as the basis for ranking questions. Ranking questions are beneficial because they require the SAs’ to evaluate potential SA responses to students in classroom scenarios and scoring can be automated. The instrument would examine a SA’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 future plans regarding validation, reliability testing, and dissemination efforts.

* Funded by NSF IUSE Grant# 1838339 Measuring and Improving Pedagogical Content Knowledge of Student Assistants in Introductory Physics Classes

PS.B-SA-6.05: Development of an Instrument for Analysis of Student Assistants' PCK-Q*

Contributed – Beth Thacker, Texas Tech University

Stephanie Hart, Kyle Wipfli, Jianlan Wang, Texas Tech University

We report on the development of a written assessment designed to analyze pedagogical content knowledge in the context of questioning (PCK-Q). We discuss the process of analyzing and coding classroom videos and writing and testing a written assessment. The classroom observations have first been coded using a coding scheme that analyzes levels of questioning in an inquiry-based classroom. A written instrument was then developed based on the classroom videos, administered to student teaching assistants (TAs and LAs) and compared with the video results to validate the written instrument. We report on the coding scheme and the validation of the instrument as part of this ongoing project.

*Funded by NSF IUSE grant 1838339 Measuring and Improving Pedagogical Content Knowledge of Student Assistants in Introductory Physics Classes

PS.B-SA-6.06: Using Research-based Assessment Tools in Intermediate Physics Courses

Contributed – Hong Lin, Bates College

The Force Concept Inventory (FCI) and the Brief Electricity and Magnetism Assessment (BEMA) were used in our sophomore-level courses on classical mechanics and electricity and magnetism, respectively, in 2020-21. Both courses used pedagogical methods to encourage interactive, engaged learning. The assessment results and students' course grades are compared. The comparison shows that the assessment tools help to diagnose weak topics in student's command of concepts. The effect of measurements that had to be taken due to the pandemic of COVID-19 on students' learning is discussed.

PS.B-SA-6.07: Procrastination Patterns Impact on Assignment Submission Times and Grade Components

Contributed – Megan Nieberding, Ohio State University

Andrew F Heckler, Ohio State University

Postponing work impacts virtually everyone at some point, especially students. We found academic procrastination is easily observed among students by studying the student's online submission times. We characterized physics student assignment completion times (ie. procrastintation) behaviors for online homework assignments into 4 completion time classes that clearly distinguish between week-to-week patterns, mean course grades, assignment completion rates, and proportion of women. Consistent with many studies, we find that procrastinating students tend to have lower course grades. Closer examination of exam and non-exam grade components reveals that exam and non-exam components are separately predicted by the two "orthogonal" measures, ACT score and completion time, and we propose that these are measuring so-called cognitive and non-cognitive factors, respectively. Identification of procrastinating students (using completion time) could be important in measuring non-cognitive factors that lead to early identification of at-risk students in physics courses.

Session: PS.B-SA-7 PER: Diverse Investigations II — Saturday, July 31, 2–3:15 p.m.

Sponsor: Committee on Research in Physics Education **Presider:** *TBA*

PS.B-SA-7.01: Can Learning Physics be Both Joyous and Uncomfortable?

Contributed – Camila Monsalve Avendaño, Michigan State University, Department of Physics & Astronomy

Vashti Sawtelle, Michigan State University, Lyman Briggs College & Department of Physics & Astronomy

Missy D. Cosby, Michigan State University, Department of Physics & Astronomy

What are the conditions for students to experience real joy in physics learning? Work from authors like Valerie Kaur & Brené Brown suggests that one of the conditions is the opportunity for students to make the continuous choice of being in the emotional discomfort of learning. In this research presentation we will explore frameworks for connecting discomfort to joy in physics learning . To ground our thinking, we will use video data from one group of students in an Introductory Physics for Life Science majors course, who are collaborating on a computational activity to understand physics concepts. We present the analysis of one student's learning experience, working on a computational activity of containing particles in a box and modeling diffusion, using a lens of joy and discomfort.

PS.B-SA-7.02: Identifying the Key Organizational Components of Informal Physics Programming

Contributed – Bryan Stanley, Michigan State University

Dena Izadi, Kathleen Hinko, Michigan State University

Informal physics programs facilitate learning spaces that allow for physicists, physics students, and public audiences to interact and engage with each other in a variety of formats, such as public lectures, summer camps and open houses. We want to understand how programs can be sustained over time, and thus, we are interested in documenting the critical organizational dimensions of informal programming, like personnel involved, audience satisfaction, and program content. To identify main challenges across programs, we conducted surveys, interviews with lead program facilitators, and site visits to multiple programs of varying formats. From emergent themes and challenges in our data analysis, we are developing and validating a model for the key organizational components of informal physics programs. In this talk, we share our current key components model of informal programs and discuss future work to develop tools for program facilitators to assess their programs.

PS.B-SA-7.03: Developing Fluency Using Multiple Representations in Geometrical Optics

Contributed – Markku Jääskeläinen, Mälardalen University

Roger Andersson, Gunnar Jonsson, Mälardalen University

A small group of secondary students learning geometrical optics with support of a computer simulation was followed. The aim of the study was to observe the students learning with a focus on their ability to correctly use rays and their reflections. The teaching was activity-based supplemented by computer simulations. Each session started with the students individually predicting the answer of the task by drawing a ray diagram and explaining in words. After turning in their predications, the students worked in pairs with the computer simulation and answered the same task again. The analysis builds on a semiotic perspective of science learning there the focus on the interaction of students and their use of the semiotic resources. How the do the students use representations to convince each other in their meaning making. The construction of the computer simulation allowed the students to focus on the representation of multiple rays.

PS.B-SA-7.04: Asking Why Students and Instructors Draw Diagrams While Problem Solving

Contributed – Michael Vignal, University of Colorado Boulder

Bethany R. Wilcox, University of Colorado Boulder

In previous work and in the literature, we have identified multiple reasons why physics problem solvers may generate diagrams as part of the problem-solving process: to orient to the problem; to serve as a tool that is manipulated to help reach an answer; to serve as a means of communication; and/or because it is a habitual part of problem solving. In this talk, we discuss a follow-up study in which we first observe students and instructors solving problems to see what role diagrams play in that process, then we explicitly ask them about their use and beliefs about diagrams generated as part of problem solving. We compare student and instructor use of and beliefs around diagrams as part of an effort to inform pedagogical approaches to teaching diagramming in physics courses.

PS.B-SA-7.05: Adapting Our Research During the COVID-19 Pandemic: Reflections and Implications

Contributed – Vashti Sawtelle, Michigan State University

Rachel Henderson, Angela Little, Camila "Cami" Monsalve, Laura A.H. Wood, Michigan State University

In March of 2020 when the COVID-19 global pandemic shut down much of the United States, academic research and research groups were also impacted. For those of us who study educational environments, and are teachers and students ourselves, we faced an unprecedented crisis. In this presentation we share how our research team adapted to the COVID-19 pandemic. We will discuss how we paused all data collection efforts, checked in with our programmatic partners about how to support their needs, and structured research group conversations about conducting ethical work in the time of COVID-19. We will also describe how we restructured what counts as work for ourselves in crisis times, and how we ultimately pivoted our research to focus on positive aspects of programs and students' experiences.

PS.B-SA-7.06: The Experience Sampling Method: Measuring the Dynamics of Students' Self-Efficacy

Contributed – Rachel Henderson, Michigan State University

Vashti Sawtelle, Michigan State University

Research has shown that students' achievement in science courses as well as their persistence within STEM fields is correlated to a student's sense of self-efficacy--the confidence in one's own ability to perform a task. Traditionally, quantitative changes in a student's self-efficacy over an academic semester have been measured using pre- and post-test surveys. However, with the complexity of the construct of self-efficacy, a pre-post design may warrant limitations in deeply understanding the impacts curricular and co-curricular activities have on students' sense of self-efficacy. To investigate the dynamics of students' self-efficacy in finer detail, we employed the Experience Sampling Method (ESM)--self-reported, in-the-moment measurements of student experiences over time. Using the results from our pilot study, we will present how we employed the ESM to measure students' self-efficacy while performing various tasks throughout the week, the validity of our measurements, and the possible versatility of the ESM within STEM education.

Session: PS.B-SA-8 PER: Diversity, Equity & Inclusion I — Saturday, July 31, 2–3:15 p.m.

Sponsor: Committee on Research in Physics Education **Presider:** *TBA*

PS.B-SA-8.01: How Perception of Learning Environment Predicts Students' Grades and Motivational Characteristics

Contributed – Yangqiuting Li, University of Pittsburgh

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 the perception of learning environment shapes these motivational beliefs of women and men. Therefore, we conducted a longitudinal study on students' motivational characteristics and grades in a two-term college calculus-based introductory physics sequence to investigate how the perception 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.

PS.B-SA-8.02: Physics Self-Efficacy of Male and Female Students Controlling for Grade

Contributed – Sonja Cwik, University of Pittsburgh

Chandralekha Singh, University of Pittsburgh

Self-efficacy has been shown to affect student engagement, learning, and persistence in various science, technology, engineering, and math (STEM) courses. Additionally prior research has shown that women have lower self-efficacy than men in STEM fields. This study examines the self-efficacy of men and women with similar performance in two introductory 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. Our findings show a gender gap in self-efficacy disadvantaging women when controlling for course grade in both physics 1 and physics 2. Additionally, most of the gender gap in self-efficacy is due to biased perceptions rather than performance in the courses.

PS.B-SA-8.03: Toward More Dyslexic-friendly Physics Teaching

Contributed – Rachel Scherr, University of Washington Bothell

Jordan Scherr, Nathan Hale High School

Dyslexia affects 5-15% of the US population (depending on how it is measured), meaning that essentially all of us who are physics instructors have people with dyslexia in our introductory courses. Through intensive tutoring of a high school student during pandemic remote instruction, I have become more aware of the physics reasoning strengths said to be common to dyslexic students, such as fluency with graphical representations. I have also become clearer on some of the barriers that typical physics courses place in the way of dyslexic students' learning, such as complex textual representations, the specialized grammar of textbook problems, and the prohibition on talking out loud during exams. In this informal talk, I will share my experiences and non-expert recommendations for making physics teaching more dyslexic-friendly.

PS.B-SA-8.04: How Goals Drive Physics Identity*

Contributed – Thomas Head, Florida International University

Joineé Taylor, Geoff Potvin, Zahra Hazari, Florida International University

Physics is not often portrayed as a field that helps individuals to satisfy communal goals, but rather is portrayed as a more self-serving career field that helps individuals achieve agentic goals. For students considering their future careers, this may dissuade more communally-driven students from pursuing a physics or physics-related career. In this study, we examine the correlations between communal/agentic goals endorsement and physics identity. As a part of the STEP UP project, data were collected from the classrooms of 16 high school physics teachers in three distinct regions of the U.S. We will present a regression model which uses goal endorsement to predict student physics identity, and how the model differs between different populations of students.

*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021

PS.A-SA-6.01: Examining Physicists' Perspectives of Career Viability and Knowledge of Impairment

Contributed – Dan Oleynik, University of Central Florida

Erin Scanlon, University of Conneticut

Jacquelyn J Chini, University of Central Florida

Physics mentors play an important role in supporting students in postsecondary education and in their transition to graduate school and careers. The knowledge and beliefs physics mentors have about disability can affect how they mentor students with impairments. We administered the Disability and Physics Careers Survey (DPCS) to 237 practicing physicists recruited through physics-specific listservs to measure their knowledge about disability and beliefs about the viability of physics careers for people with different types of impairments. This study compares practicing physicists' varied knowledge about different categories of impairments and diagnoses, and their beliefs about the viability of future careers for students with specific categories of impairment. We will present our findings examining the relationship between physicists' knowledge about the categories of impairment and their beliefs on the variability of career and research prospects for students with impairments within that category.

PS.B-SA-8.06: How Early Physics Identity Constructs Predict Later Identity Constructs*

Contributed – Joineé Taylor, Florida International University

Pooneh Sabouri, T. Blake Head, Geoff Potvin, Zahra Hazari, Florida International University

Cross-sectional physics identity studies have shown that interest and recognition are essential to the development of students' physics identity To explore how these and other affective factors shape physics identity over time, we conducted a time-series analysis using Structural Equation Modeling (SEM) on pre-and post-survey data collected from 1979 students in Fall 2018 from 16 high school physics classes across three regions of the US. More specifically, we measured constructs related to high school physics identity (recognition, interest, performance/competence beliefs, utility value, future intentions) as well as the association of post-survey constructs to the likelihood of persisting to a physics major in college.

*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, and 1721021.

PS.B-SA-8.07: From Land Acknowledgments to Action: Engaging with Indigenous History

Contributed – Jessica Hernandez, University of Washington, Bothell

Rachel Scherr, University of Washington, Bothell

Amy D. Robertson, Seattle Pacific University

Land acknowledgements are verbal and written statements that recognize and respectfully acknowledge Indigenous peoples whose ancestral lands were stolen and are now occupied. Indigenous scholars and communities have called for land acknowledgements to inspire action to support justice for present-day Indigenous communities, while acknowledging the history of genocide and settler colonialism. In a professional learning community, we helped secondary physics teachers develop land acknowledgements into a praxis, in which they not only verbally acknowledged the Indigenous lands they were occupying, but also took actions to bring to the forefront the Indigenous history of the lands they are currently teaching into their physics classrooms. The learning and praxis occurring in our professional development contrasts with performative land acknowledgments, in which there are only verbal or written statements made.

POS.F-MO.06: Who Do Students Believe a Growth Mindset Applies To?

Contributed – Alysa Malespina, University of Pittsburgh

Christian Schunn, 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. This suggests a shift towards a fixed mindset after taking an introductory course. This shift was most pronounced for self-focused items. Women shifted more towards a fixed mindset than men did. Over the semester, gender disparities in mindset emerged or widened. Results were similar for algebra- and calculus-based courses. More women than men took algebra-based physics, so gender disparities likely result from teaching practices and department culture, not only underrepresentation of women.

Session: PS.B-SA-9 PER: Student and Instructor Support & Professional Development, Program and Institutional Change I

Saturday, July 31, 2–3:15 p.m. Sponsor: Committee on Research in Physics Education Presiders: *TBA*

PS.B-SA-9.01: Remote GTA Preparation: The Good, the Bad, and the Ugly

Contributed – Emily Alicea-Munoz, Georgia Institute of Technology

The COVID-19 pandemic necessitated a move to remote/online instruction beginning in the middle of the Spring 2020 semester. As a result, the Fall 2020 cohort of first-year physics PhD students, who would also be graduate teaching assistants (GTAs) for the first time, had to both attend their graduate coursework and teach their assigned labs and recitations remotely. Our Physics GTA Preparation course, a robust and comprehensive program that has been running since 2013 and integrates pedagogy, physics, and professional development strategies, had to be modified in terms of content and delivery to adjust to the present situation. In this talk, I will briefly describe our regular GTA preparation course, the changes made for online instruction, and the things that worked or didn't work in the modified curriculum.

PS.B-SA-9.02: Effectiveness of Action Research and RTOP for Improving Physics Lessons

Contributed – Sachiko Tosa, Niigata University

High school teaching in Japan is traditionally known as teacher-driven. To improve the situation, the new Course of Study for high schools, which will be fully implemented in 2022, emphasizes the importance of active learning and inquiry. This study examines the effectiveness of the use of action research and RTOP (Reformed Teaching Observation Protocol) for improving high-school physics lessons in Japan. Three action research sessions were conducted for a particular Basic Physics class in two months. The results indicate that the RTOP scores improved dramatically as action research progressed, especially in the areas of teacher's procedural knowledge and student-student interactions. The teacher's attitudes towards active learning and collaboration also showed an improvement. Discussions on the difficulties of helping teachers have student-centered views in physics teaching will be included in the presentation.

PS.B-SA-9.03: Teacher Use of Resources While Integrating Computational Modeling into Classrooms

Contributed – Julia Willison, Michigan State University

Marcos D. Caballero, Michigan State University

David Stroupe, Julie Christensen, Sunghwan Byun, College of Education, Michigan State University

Computational modeling is increasingly becoming a critical and necessary component of a physics education. Integrating Computation in Science Across Michigan (ICSAM), an NSF-funded program at Michigan State University, aims to help high school teachers bring computational modeling to their physics classrooms. In this presentation, we illustrate the kinds of resources that participating teachers used to integrate computation in their physics teaching through a case-study analysis of a particularly active teacher participant. Through the past two years, we observed and recorded participating teachers' journeys in classroom videos, interviews, and other data. We examined the data using emergent coding to characterize the resources that these teachers have used while integrating computation into their classrooms and how these resources have changed over time. Through this work, we aim to share implications for professional development providers, curriculum developers, and practicing teachers. This work was supported by the National Science Foundation (DRL-1741575).

PS.B-SA-9.04: Measure Student Assistants' PCK-Q in Online Settings During COVID Pandemic

Contributed – Jianlan Wang, Texas Tech University

Beth Thacker, Stephanie Hart, Kyle Wipfli, Texas Tech University

Student Assistants (SA), including graduate and undergraduate teaching/learning assistants, are pivotal to non-traditional physics instruction in large classrooms. In this study, we used the framework of Pedagogical Content Knowledge for questioning (PCK-Q) to measure SAs' questioning skills. We designed a written instrument describing various situations that SAs would encounter while interacting with students. SAs needed to articulate how they would support student learning considering their difficulties. We also developed a coding scheme to analyze how SAs' questions leveraged students' conceptual understanding. We administered this written instrument with SAs who had various years of experience in inquiry-based physics courses and analyzed their videos of interacting with students in online settings during the COVID pandemic. We validated the written instrument with class videos, delineated the SAs' PCK-Q, and suggested how the SAs' questions contributed to students' conceptual learning about classical mechanics and electromagnetism.

PS.B-SA-9.06: Identifying Shifts in Agency In the STEP UP Ambassador Program*

Contributed – Ben Archibeque, Florida International University (FIU)

Joinee Taylor, Pooneh Sabouri, Zahra Hazari, Florida International University (FIU)

Anne Kornahrens, American Physical Society

For decades, undergraduate physics programs have struggled with the underrepresentation of women. The STEP UP project (STEPUPphysics.org) was designed to reduce barriers for women in physics and encourage high school women to pursue an undergraduate physics degree. STEP UP focuses on implementing high school interventions by working with cohorts of high school physics teachers, called Ambassadors, who are trained to teach and propagate STEP UP's research-driven materials throughout their networks. To understand the effects of training, surveys were administered to Ambassadors throughout the school year. Taking a "tempered radicals" framing, this talk will present an analysis of survey responses including how they changed after completing their Ambassadorship and how this information can be used to identify teachers who are willing to disrupt the status quo. Results should help other programs seeking to develop "tempered radicals" in their communities.

*This work is supported by the National Science Foundation under Grant No. 1720810, 1720869, 1720917, 1721021, and 1038321.

PS.B-SA-9.07: Transitions to Online Physics Teaching: Empathy and Above Average Quality*

Contributed – E Eric Brewe, Drexel University

Adrienne L Traxler, Wright State University

Sarah Scanlin, Drexel University

We surveyed a national sample of United States physics faculty about the COVID-19 transition to online learning. The majority of faculty had 1-2 weeks to prepare and no prior experience with teaching online. They relied on department peers to discuss approaches and used lecture adaptations such as videoconferencing rather than new curricular elements. Their responses were empathetic to the students' situation, and 90% said they were average or above at implementing online instruction. Faculty's preference for local resources and existing methods suggests that in a crisis, strong network ties will dominate as information sources, with consequences for professional development and instructional change.

*This project is supported by NSF DUE 2027958 and DUE 2027963.

Session: PS.B-SA-10 PER: Student Content Understanding, Problem-Solving and Reasoning II

Saturday, July 31, 2–3:15 p.m. Sponsor: Committee on Research in Physics Education Presiders: *TBA*

PS.B-SA-10.01: Student Conceptual Connections Within and Between Quantum Notations*

Contributed – William Riihiluoma, University of Maine

John R Thompson, University of Maine

As part of an effort to examine student understanding of mathematical representations in quantum mechanics, online survey tasks were designed and administered to students at the end of their upper-division QM courses at several institutions. Virtual task-based clinical interviews were also conducted in the following semester with students at the University of Maine. Tasks were designed to find expressions and concepts that were related or viewed as similar in students' minds, and to determine what concepts were ascribed to various expressions. Geometric concepts, including vectors and dot products, were used to describe various expressions, as were physical concepts such as quantum states and probabilities of physical measurements. Multiple physical and mathematical concepts were often invoked for a single expression, and vice versa. Sherin's symbolic forms framework was used to guide analysis, and potential symbolic forms used by students for expressions in both Dirac notation and wave function notation were identified.

*This material is based upon work supported by the National Science Foundation under Grant No. PHY-1912087.

PS.B-SA-10.02: When Scaffolding Doesn't Work*

Contributed – Paula Heron, University of Washington

Kristin Kellar, University of Washington

Instructors use many tactics to help guide students through the process of systematically analyzing complex physical situations. One tactic is to provide a series of intermediate "scaffolding" steps that suggest the structure of a specific line of attack. Another is to invoke a simpler, more familiar, or more concrete problem; noting similarities to the target task could help students distinguish surface features from deeper structure. In the short-term, these tactics are intended to enhance performance on the target tasks. In the longer-term, they are intended to help students recognize a general approach they can later apply independently. However, research on effectiveness is mixed. This talk focuses on a case in which scaffolding was not helpful. Evidence from language use and answer patterns suggests that while the reasoning chain implied by the scaffolding questions makes sense to an expert, it was not well-aligned with the spontaneous reasoning of many students.

*This work has been supported by NSF DUE 1821123.

PS.B-SA-10.03: Computation to Support Understanding of Discrete and Continuous Quantum Systems

Contributed – Christian Solorio, Oregon State University

David Roundy, Elizabeth Gire, Oregon State University

From our experience teaching the spins-first Paradigms quantum mechanics course, students run into difficulties transitioning from discrete to continuous quantum systems. In computation, continuous structures like wavefunctions are necessarily discretized in order to be used in operations like numerical integration. Because of this feature, we believe that computation may naturally support the transition. Junior-level students at Oregon State University take a computational lab course where they numerically solve quantum mechanics problems by pair-programming in Python. This computational lab course is coordinated with the spins-first Paradigms course. We remotely interviewed six participants at the end of the courses. Participants completed a card-sorting task where they organized twenty cards with a variety of quantum mechanics content and representations. In this talk, we will discuss the ways participants organized this information, the overarching patterns, and the ways that students understand and coordinate discrete and continuous quantum systems.

PS.B-SA-10.04: Color-Coding and Student Perceptions of Learning in Introductory Mechanics

Contributed – Brianna Dillon Thomas, Coastal Carolina University

In this study I surveyed student's perceptions regarding the helpfulness of a color-coding scheme for introductory mechanics instructional materials. The use of color and color-coding (presenting corresponding items in different representations in the same color) has been shown to aid student learning through research in psychology and related disciplines, but little has been done to systematically study its effect within physics education. Color-coding was employed in three areas: matching words in physics principles with variables in their corresponding equations, matching equation variables with their corresponding representation in physics diagrams and pictures, and separating components in two-dimensional physics problems. Approximately 40 students over two semesters were anonymously surveyed regarding the perceived benefits and distractions of these three color-coding schemes. Students' responses were majority positive, and identified the color-coding as helpful in engaging their attention and in identifying, matching, sorting, and tracking new information.

PS.B-SA-10.05: How Modeling Informs Students' Engagement in Sensemaking

Contributed –Amogh Sirnoorkar, Kansas State University

Paul Bergeron, Michigan State University

James T Laverty, Kansas State University

Sensemaking– the process of generating new knowledge by ascertaining the underlying mechanism of a phenomenon– should be an integral part of students' academic experience. In this work, we highlight an introductory physics student's sensemaking on a physics problem through the framework of sensemaking epistemic game. The analysis of the student's approach across the four stages of the epistemic game reflects modeling of the problem context guided by a diagram. The process of modeling is found to involve three components: (i) denoting the physical entities (forces) through symbols, (ii) establishing the mathematical relationships between these symbols and (iii) inferring the physical meaning of the obtained relations. Through this observation, we argue that sensemaking involves engaging with all the three components of modeling. We also note the implication of this study on designing tasks that have the potential to nudge students towards engaging in sensemaking.

PS.B-SA-10.06: Exploring Student Conceptual Resources About Heat and Temperature*

Contributed – Mikayla Valentin, Seattle Pacific University

Yohannes M Abraham, Brynna Hansen, Amy D Robertson, Seattle Pacific University

Lauren C Bauman, University of Washington

Previous literature about students' understanding of heat and temperature emphasizes students' misunderstandings of canonical physics concepts. In our study, we used a resources-oriented approach to analyze data from 653 students' responses to questions about thermal phenomena, highlighting ways in which their responses could serve valuable resources for continued learning. We categorized our findings into four common conceptual resources. These resources can be used to strengthen teaching methods by using students' understanding of heat and temperature, to foster their learning processes and help them to develop more advanced physics ideas.

*Supported by NSF Grants No. 1914603 and 1914572

PS.B-SA-10.07: Student Resources for Understanding Momentum*

Contributed – Brynna Hansen, Seattle Pacific University - Seattle, WA

Lauren C. Bauman, University of Washington

Mikayla K. Valentin, Yohannes M. Abraham, Amy D. Robertson, Seattle Pacific University

Much existing physics education research (PER) on student ideas about momentum focuses on the difficulties that students face when learning this topic. These difficulties are framed as obstacles for students to overcome in order to develop correct understandings of physics. Our research takes a resources-oriented approach to analyzing student responses to momentum questions, viewing student ideas as valuable and potentially productive for learning, over and above correctness. In this talk, we highlight four conceptual resources that provide insight into students' ideas about momentum. These resources are context-dependent, and can be elicited and built on by instructors to support students in developing more complex and sophisticated understandings of physics.

*Supported by NSF Grants No. 1914603 and 1914572

PS.B-SA-10.08: Multidimensional Item Response Theory and the BEMA: Modeling Student Thinking

Contributed – John Hansen, West Virginia University

John Stewart, West Virginia University

This study applies Multidimensional Item Response Theory (MIRT) analysis using confirmatory methods to the Brief Electricity and Magnetism Assessment (BEMA) to explore the assessment's structure and to determine an optimal model of student knowledge measured by the assessment. These methods were used to investigate a large dataset (N=9666) from a research university in the western United States. Confirmatory MIRT analysis fit a theoretical model developed from expert solutions to the instrument and identified two optimal models: an optimal principle model and an optimal topical model. The optimal principle model consisted of 28 principles, fundamental reasoning steps needed to solve items in the BEMA. A second model, the optimal topical model, consisted of five general subtopics of electromagnetism. Both the optimal principle and optimal topical model had excellent fit statistics.

Session: PS.B-SA-11 Spiral Physics and Parallel Pedagogy — Saturday, July 31, 2–3:15 p.m.

Sponsor: Committee on Physics in Two-Year Colleges **Presiders:** *Dean Stocker, Kris Lui*

PS.B-SA-11.01: Spiraling Conservation of Energy/Mass in Introductory Physics: Kirchhoff to Bernoulli

Contributed – A. Tabor-Morris, Georgian Court University

Building on my presentations in the past, I argue that students can become more grounded in physics by the realization of that multitude of physics equations which can be regarded in terms of the Law of Conservation of Energy or Conservation of Mass. Examples of this are in Kirchhoff's two Laws of Electricity in terms of, respectively, voltage loops which is scaled per charge and current splitting scaled per time. Another set of complementary examples is in fluid dynamics regarding, respectively, Bernoulli's Equation which is scaled per volume and the Continuity Equation scaled per time (see also Poster Session for details). Revisiting these Conservation Laws also underscores their broad importance and aids in student recall and additional application into the future. Examples of potential confusions and pitfalls for teachers to be aware of are given.

PS.B-SA-11.02: Spiral Physics in the Classroom

Invited – Mary Mohr, Monroe Community College

The Spiral Physics series of workbooks serve as the main textbooks for many of the physics courses at Monroe Community College. These workbooks were developed by Paul D'Alessandris while he was a physics professor at Monroe Community College and have since then replaced standard textbooks in both freshman and sophomore level courses at this institution. The Spiral Physics workbooks emphasize multiple representation problem solving techniques, restrict students to a small set of fundamental equations, and use goal-less problem statements. The workbooks for mechanics courses arrange topics such that students receive repeated exposure to concepts throughout the course. On each spiral through the material the complexity is increased. This talk will address strategies for implementing Spiral Physics as the primary textbook in both algebra-based and calculus-based physics courses.

PS.B-SA-11.03: Parallel Pedagogy: Seven Years, and 1000 Students Later

Invited – Pete Schwartz, Cal Poly Physics

Jennifer Klay, Owen Staveland, Cal Poly Physics

Parallel Pedagogy Introductory Mechanics [P. Schwartz, *TPT*, 55, 280 (2017)]:
- Simultaneously introduce momentum, energy, dynamics, kinematics on the first day;
- build complexity while repeating process in following order: rotation, systems, components, trigonometry, the two quadratic kinematics equations;
- require full conceptual support, rather than correct answer, for credit;
- engage students at home with interactive videos and textbook, reserving class time for group work, demonstrations, discussion;
- learning assistants model learning process, stimulate conversation.

After 16 classes, >900 students.
- Most students prefer this method.
- CLASS (Colorado Learning Attitudes about Science Survey, http://www.colorado.edu/sei/class/) results indicate improvement – especially applied conceptual understanding.
- Students demonstrate superior concept application (Pedagogy Changes Can Improve Concept Application, O.Staveland, P.Schwartz, TPT, submitted)
- Using publicly-available text and interactive videos, a first-time mechanics instructor seamlessly and successfully adopted parallel pedagogy.

AAPT July 2020 presentation: https://www.youtube.com/watch?v=Ab3ZtCXlelU
Resources: http://sharedcurriculum.peteschwartz.net/parallel-pedagogy/

PS.B-SA-11.04: Using OER Materials, Perusall(R), and myOpenMath with Parallel Pedagogy

Invited – Dean Stocker, University of Cincinnati Blue Ash College

I will speak briefly about why I like the approach of parallel pedagogy, then provide a link to a Perusall(R) course that I have set up just for the meeting, populated with some or all of the OER textbook I'm using for my introductory physics classes. I'll highlight the format of the book and explain the motivation behind the formatting. Then I will share examples of student work that follow the pattern of analysis used in the book. I will also show how I use Perusall(R) for asynchronous interactions and myOpenMath for immediate feedback to students. A revised version of the textbook will be presented at the meeting; last year's version is available at http://sharedcurriculum.peteschwartz.net/wp-content/uploads/sites/3/2020/07/Physics-in-Four-Part-Harmony-2020-reduced.pdf.

Session: PS.B-SA-12 Using Educational Technology to Enhance Diversity, Equity, and Inclusion

Saturday, July 31, 2–3:15 p.m. Sponsor: Committee on Educational Technologies Presider: *Shahida Dar*

PS.B-SA-12.01: Educational Technology to Support DEI at Course and Institutional Levels

Contributed – Melissa Eblen-Zayas, Carleton College

Laura Muller, Williams College

When well-implemented, educational technology can enhance equity and inclusion by increasing flexibility and expanding the modes of engagement for learners. This talk will provide an overview of two efforts to use educational technology to support the quantitative skills development of students within a residential liberal arts college. At the course level, online modules give students the opportunity to review and practice quantitative skills in a manner that reduces barriers for student engagement, but faculty framing of the modules impacts student perceptions and usage. At the institutional level, an online summer bridge program to support incoming students in strengthening their quantitative skills provides flexible engagement opportunities for students who have significant work or family responsibilities. This talk will summarize some key lessons learned from these two efforts (online modules and online bridge program) that may be relevant to other efforts focused on harnessing educational technology to enhance DEI goals.

PS.B-SA-12.02: Use of Physics Simulations in Supporting Equity and Student Learning

Contributed – Emily Allen, The Governor's Academy - Byfield, MA

Andrew Duffy, Manher Jariwala, Vera Degtiareva, Boston University

heila Sagear, University of Florida

Computer simulations have been used to support student learning in physics, not only to boost conceptual understanding but to make labs more widely accessible to different populations. However, their impact on student learning has shown mixed results. To better understand this impact, HTML5-based computer simulations for topics in mechanics were investigated in a large, algebra-based, studio physics course for life science students at a private, research-intensive institution. Over a period of three years, we compared learning outcomes of students using traditional hands-on equipment only, a simulation only, or a hybrid combination of both for activities on energy, momentum, simple harmonic motion, and rotational dynamics. We will present our findings of this study through an equity lens, both from the experience of online learning due to the global pandemic and from consideration of the limited access to lab equipment for many students.

PS.B-SA-12.03: Facilitating Online Learning Communities in Large-enrollment Introductory Physics Courses*

Contributed – Yasmene Elhady, University of Washington

Suzanne White Brahmia, University of Washington

The sudden transition to remote instruction left many students struggling to fully engage with courses which had fewer opportunities for meaningful interpersonal interactions. In response, we formed “Learning Pods – online learning communities of small student groups connected through Slack and mentored in collaboration skills. Subsequently, Learning Pods became an organizing structure of the introductory calculus-based mechanics course. Features of the Learning Pod Intervention varied as we scaled up from courses with ~100 students to those with 300-500 students. Based on analysis of student survey questions, we present preliminary indicators of increased student self-efficacy and improved engagement with instructors and peers. Improved self-efficacy and engagement have been correlated with improved success and persistence, especially for students from groups underrepresented in physics. We observe that different implementations increased student self-efficacy to different degrees, and that instructor and TA engagement in mentoring effective collaboration lowered barriers for students’ engagement with TAs.

*This work is supported in part by the University of Washington Curricular Commons Innovation Fund, 2020

PS.B-SA-12.04: The APS/IBM Research Internship for Undergraduate Women and Under-represented Minorities

Invited – Barbara Jones, IBM Quantum

The APS/IBM Research Internships have been continuing for 14 years. These internships, in partnership with the American Physical Society, bring in undergraduates after their sophomore and junior years for a summer internship in the IBM Research Division. The internships are in a wide range of STEM subjects, from psychology to mathematics to quantum computing, in addition to the largest numbers in chemistry and physics. I will describe how the technologies used for the application and admissions processes have changed over time, and in particular how the current technology assists in getting a very broad representation of students from across the country. Our aims are specifically to celebrate the benefits of diversity, equity, and inclusion in technology fields, and our use of educational technology continues throughout the summer for the students with a range of learning and interaction opportunities which I will present, and which are subject to continuous improvement.

Session: SPS.A.SA SPS Undergraduate Special Session Saturday, July 31, 3:30–5 p.m.
Sponsor: AAPT/SPS **Presider:** *Brad Conrad*

SPS.A.SA.01: Muon Path Detection in a Magnetic Field

Poster – Henry Seiden, Glenbrook North High School

Ava Stumpf, New Trier High School

Anthony Valsamis, Glenbrook North High School

Nathan A Unterman, New Trier High School

Students from two nearby high schools designed and configured QuarkNet cosmic ray muon detectors to measure any changes in cosmic ray flux due to an inserted 0.1T magnetic field. The design included two separate methods to measure differences in muon path. We hypothesized that the neodymium magnetic field would vary muon flux in an offset detector array. Results will be presented.

SPS.A.SA.02: An Analytical Approximation of Gravitational Waves

Poster – Daniel Hancock, Bridgewater College

Deva O'Neil, Bridgewater College

The goal of this project is to integrate pre-existing analytical models of gravitational waves into Python so that undergraduate students have access to a model for gravitational waves that is straightforward and easy to understand. To facilitate this, we break the problem into two phases, the inspiral and the merger-ringdown. The inspiral phase is modeled using Post-Newtonian (PN) theory. The merger-ringdown phase utilizes an analytical model called the Implicit Rotating Source (IRS) that creates an analytical fit to data created by numerical relativity. To create the final waveform, we use two different matching techniques to combine the merger-ringdown and inspiral waveforms. Future students can use this template we have created to test the generated waveform with experimental data, create solutions for parameters such as non-zero eccentricity, statistically determine the accuracy of the matching technique, and conduct a wide variety of other research projects.

SPS.A.SA.03: Physics Education Research as Preparation for a Future Physics Educator

Poster – Ian Coburn, University of New Hampshire

Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Dawn Meredith, University of New Hampshire

Over the course of the past semester, I have been working with the University of New Hampshire's PER research team, led by Prof. Dawn Meredith to complete my senior capstone project, required for graduation. As part of this team, I have focused on preparing for and conducting interviews to improve fluids education for Introductory Physics for Life Science Majors courses. As part of an NSF funded project, members of the team expect to interview approximately 140 students from at least 14 separate institutions across the United States to evaluate how students think about various topics. To obtain a truly representative sample of life science students, these institutions are in several regions of the country. As someone who hopes to have a career in education, this project has granted insights into the thought processes of students that should carry forward into a teaching position.

SPS.A.SA.04: "The Compleat Physicist" – A Learning Framework for Human Impact

Poster – Randy Tagg, University of Colorado Denver

Physics has proven itself capable of profound impact on human well-being. How might student physicists structure their learning to maximize their capacity to enjoy an intellectually stimulating career while actively solving important human problems? The "Compleat Physicist Model" suggests three major domains of learning. First is the foundational domain that is the core of our existing curriculum: analytical, computational, and laboratory learning aggregate to create this foundation. This domain should be increasingly mirrored by student experiential learning in an applied domain where major areas of human activity are identified and the potential for physics-based contributions explored. The third competency domain connects foundations to applications: students forge an individual repertoire of practical skills to translate physics into useful technologies. The goal is to unify these domains so that students emerge with a strong interest and sense of efficacy in improving the world in which they live.

AAPT AWARDS

Presider: Chandralekha Singh

Paul W. Zitzewitz Teaching Award – Brad Talbert

Brad Talbert

Sunday, August 1
11 a.m.–12 p.m.

Physics Is the Portal

Early physics instruction (9th or 10th grade) opens doors to higher achievement in chemistry, math, advanced biology, and engineering. As students learn to organize complex information to find solutions to assigned problems and engineering tasks, they improve abstract reasoning skills and gain increased self-confidence. A first experience with physics ought to include challenging mathematical structure but also provide many concrete hands-on learning experiences.

Halliday and Resnick Teaching Award – Anne Cox

Anne Cox

Mission Possible

When you know your mission, you know what you do better than, different than, other than… for you alone do." (attributed to Robert Hutchins, President of the University of Chicago, 1929- 45) What is it that we, physics teachers, do that is unique—what is our mission and why have we chosen to accept it? I will reflect on what I have learned about physics teaching from many of you as I celebrate our joint mission, share pedagogical strategies, and highlight challenges ahead. This talk will be grounded in the tools of our trade: simulations, laboratories, video analysis, and makerspaces. But it will also acknowledge the human side of physics and the ways in which we connect with each other and our students, particularly through mentoring and JEDI-B work (Justice, Equity, Diversity, Inclusion and Belonging). And yes, there may be a Star Wars reference or two along the way. "Access to a dark night sky—to see and be inspired by the universe as it really is—should be a human right, not a luxury for the chosen few." (Chanda Prescod-Weinstein, *The Disordered Cosmos,* p. 165)

Session: PS.C-SU-1 Computation in Quantum Mechanics **Sunday, August 1, 12:30–1:45 p.m.**
Sponsor: Committee on Contemporary Physics **Presider:** *Jay Wang*

PS.C-SU-1.02: Teaching Quantum Mechanics in an Experiential Learning and Engaging Environment

Contributed – Mehdi Ayouz, Centralesupélec

Jean-Michel Gillet, Pierre-Eymeric Janolin, Centralesupélec

Viatcheslav Kokoouline, University of Central Florida

We developed a number of digital tools to support teaching quantum mechanics. The idea behind that is main concepts of quantum mechanics are non-intuitive to an uninitiated student due to the lack of daily experience with quantum mechanics: The basis of intuition is experience. Therefore, teaching quantum mechanics with a support of numerical experiments for all main topics of quantum mechanics appears to be essential for an efficient and quick learning process. The numerical experiments are prepared using PYTHON computer codes and a graphical interface. Students and instructors can use the graphical interface to change parameters of the suggested numerical experiments or they can download, modify and run the codes on their personal computers. Finally, a website, gathering overall numerical experiments, was designed. It can be used by universities and institutions in their different educations.

PS.C-SU-1.02: Dynamics of Wave Packets Propagating in Linear and Hyperbolic Potentials

Contributed – Juan Serna, The University of Scranton

In quantum mechanics, we use wave packets to represent how particles are localized in a specific region of space. When particles interact with potentials, the wave packets propagate in space and time, undergoing different physical processes typical to waves like dispersion, reflection, and interference. I present a computer program that simulates a one-dimensional wave packet propagating in constant, linear, and hyperbolic potentials. Instructors can use this program in undergraduate-level courses (modern physics and quantum mechanics) to explore the quantum evolution of different types of wave packets (Gaussian, sech2, and square) and demonstrate quantum interference effects.

PS.C-SU-1.03: Multimodal Computation in Quantum Mechanics

Contributed – Jay Wang, University of Massachusetts Dartmouth

Computation has delivered many benefits to the teaching and learning of quantum mechanics. It increases students' engagement with the subject matter, enabling them to be doers as opposed to just thinkers or traditional problem solvers. In many cases, practices, tools and methods previously used only in research have been brought to the classroom, significantly enriching the class. In this presentation we will discuss multimodal techniques, some successfully used in atomic physics, to computation in quantum mechanics, including visual, numerical, and symbolic computation. We will present select activities and projects on large eigenvalue problems, scattering, and time-dependent dynamic evolution. Working examples will be given in Python but the templates should be adaptable to other platforms.

PS.C-SU-1.04: Implementation and Assessment of Computation in a Modern Physics Course

Invited – W. Brian Lane, University of North Florida

Cortney Headley, University of North Florida

Many of us remember passively wading through a lengthy and esoteric derivation of the energy eigenstates of the harmonic oscillator, which we likely revisit only when teaching the topic. In contrast, a computational introduction engages students in a dynamic investigation that immediately produces visualizations in a process they can repeat ad infinitum for any number of potential energy functions. In this talk, I share my recent iteration of a junior-level Modern Physics course, for which I created a sequence of computational assignments based on published PICUP Exercise Sets, developed a new Exercise Set about x-ray crystallography, and implemented a revise-and-resubmit structure for assignment grading. I conclude with a discussion of assessment interviews I conducted after the course to examine the ways in which computation helped the students learn challenging quantum concepts, and discuss needs to address in future semesters.

PS.C-SU-1.05: Liberating Undergraduate Quantum Mechanics through Computation

Invited – Daniel Schroeder, Weber State University

Today's computational tools give us tremendous freedom in designing a quantum mechanics course for undergraduates. We can explore a much wider range of applications, jettison arcane pencil-and-paper drudgery, create magnificent visualizations, probe more deeply into the fundamentals of the theory, and send students away with highly marketable skills. In this talk I'll show some of my favorite examples and share some teaching tips for a computationally intensive quantum mechanics course. (Materials related to this talk are posted at https://physics.weber.edu/schroeder/quantum/.)

PS.C-SU-1.06: Integrating Computation into a Spin First Undergraduate Quantum Mechanics Course

Invited – Jarrett Lancaster, High Point University

I will describe a first attempt to build computation into the undergraduate quantum mechanics course at High Point University. In a spin first approach, students uncover the postulates of quantum mechanics entirely in the context of spin-1/2 degrees of freedom before developing position-space wave function technology needed to study the standard array of potential wells. This non-standard approach to teaching quantum mechanics is particularly well suited for the integration of computation. In addition to presenting several examples of how integrated computational exercises can aid in student understanding of key ideas in quantum mechanics, I will share some possible independent projects involving advanced topics which are accessible to students well versed in the basic computational methods used to investigate spin.

Session: PS.C-SU-2 Current Topics in Physics for all Ages — Sunday, August 1, 12:30–1:45 p.m.

Sponsor: Committee on Physics in Pre-High School Education **Presider:** *Shawn Reeves*

PS.C-SU-2.01: Explaining Physical Phenomena Happening on Earth and in Space

Contributed – Georgios Kontokostas, National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimiopolis, Zografos, Greece,

Geosciences can explain macroscopic phenomena occurring on earth and in space. Geosciences can interpret physical phenomena like tides, magnetic poles, life on other planets and earth rotation. Our research is involving group of students of a secondary school of Attica. The control group was also the experimental group. This work is an attempt to follow research steps by inquiry – based learning: a) trigger of interest, b) reminding of basic knowledge/formulation of hypothesis, c) experimentation/trials d formulation of conclusions, e) applications/generalization according to learning.

PS.C-SU-2.03: Traditional and Digital Physics Homework in Secondary School

Contributed – Dorottya Schnider, ELTE University*

Mihály Hömöstrei, ELTE University

Due to the advances in digital technology, many new perspectives have been opened in the educational system. The use of digital devices in the classroom can enhance the level of classes and increase our students' attitude towards Physics. As the pandemic situation proved, it is essential to rely on digital teaching methods. The study discusses the effect of digitalized education on students' academic performance and cognitive development, investigates the role of handwriting in education – focused on homework solving – and compares it with the opportunities given by using digital methods. The research was carried out in Budapest among 7th graders to investigate how the traditional and digital homework solving methods contribute to academic success and motivation. The study raises attention on that although the use of digital technology in education can have positive effects, there are parts of the learning process where the traditional methods are essential.

*KDP-2020 Doctoral Scholarship - Ministry for Innovation and Technology, Hungary

PS.C-SU-2.04: A Thermodynamics Approach to Introducing the Climate Crisis

Contributed – Frank Lock, Gerogia State University Woodrow Wilson Fouindation

This presentation will provide an overview of presentations that are available to those attending for use with their classes. The presentations are designed for students in grades 6-8, 9 – 12, and college introductory physics courses, and the general public. Climate science challenges are presented in terms of thermodynamics/entropy changes that occur due to procuring and burning fossil fuels to produce electricity. Information about the Climate Reality Project will also be included.

PS.C-SU-2.05: Superposition With Sporks: 3rd Graders' Analogical Models of Quantum Superposition

Contributed – Devon Christman, University of California Santa Barbara

Danielle Harlow, University of California Santa Barbara

Quantum computing is becoming an increasingly important field of study poised to revolutionize the computing industry. With the rise of quantum technology, we are seeing the need for a more developed quantum literate workforce. However, simply introducing basic computing concepts to young learners is not enough, as quantum computing requires that computer scientists learn an entirely different way to program with new and complex constraints. Many of these new methods require not only a basic understanding of computing, but also a deeper understanding of quantum physics as well. Ideas such as reversibility, entanglement, measurement, and superposition are fundamental building blocks for creating a deeper understanding of quantum computing. This study used data collected from a large, urban, 3rd grade classroom located in the Midwestern United States to examine how students create their own analogical models of quantum superposition and to what extent these models show their understanding of superposition.

PS.C-SU-2.07: Report on Pilot Study for Semiclassical Tic-Tac-Toe Online Module

Contributed – Joshua Qualls, Morehead State University

The use of educational games has a rich history in physics education, and appropriately-designed activities help build student intuition for quantum mechanics without the difficult prerequisite mathematics. In this work, we report the results from our pilot study on the development and implementation of a semiclassical tic-tac-toe online module for introducing quantum computing. Although a quantum version of tic-tac-toe has been studied, its steep learning-curve can overwhelm students new to quantum concepts. We designed an intermediate "semiclassical" tic-tac-toe to bridge the classical and quantum versions of the game in hopes of more gradually building knowledge/skills. The delivery and lesson content of our module show promise, and design is currently underway for a complete research study investigating the effectiveness of semiclassical tic-tac-toe as an intervention. This design includes suggestions and improvements from the pilot study, including streamlining the content, making the game activities more interactive, and improving the graphical design.

PS.C-SU-2.08 Fractional Calculus Approach in Supercontinuum Generation in Photonic Crystal Fibers

Contributed – Andrés González García, Universidad de Guanajuato

J Juan Rosales García, Gerardo G González-García, Universidad de Guanajuato

Ernesto Sánchez García, Instituto Tecnológico Superior de Guanajuato

Ismael Urbina-Salas, Instituto Tecnológico Superior de Guanajuato

In this work, we present another way to solve by numerical development for the supercontinuum generation (SC) is demonstrated by developing fractional calculus for a photonic crystal fibre of hexagonal design. The solutions are presented temporal and frequency domain of the Nonlinear Schrödinger Equation (NLSE). The results show that, for a spectral development of the NLSE, greater computational savings and analysis of the phenomena that intervene in the generation of this non-linear effect are obtained.

Session: PS.C-SU-3 "Ooh I Want to Try That!" Best New Labs We've Seen

Sunday, August 1, 12:30–1:45 p.m.

Sponsor: Committee on Physics in High Schools **Presider:** *Bree Barnett Dreyfuss*

PS.C-SU-3.01: Group-Worthy Physics Challenges

Invited – Joe Cossette, Minnetonka High School

Engaging physics classes with mysteries, scavenger hunts, and escape rooms - This session will share several examples of tasks that present content in a way that requires a group to collaborate fully. Whether it is a murder mystery using kinematics to piece together a crime scene, or a virtual escape room about circuits that each teammate receives their own unique role, the common feature of all of these activities is that every member of the group must be involved in a meaningful and authentic way for the group to find success. All of the lesson materials will be shared to explore and modify.

PS.C-SU-3.02: Gamify, Don't Simplify: Virtual Activities for Student Intuition & Motivation

Invited – Matthew Blackman

Looking for ways to help your students develop their intuition for physics concepts? Virtual activities that you can assign for homework and students will actually enjoy doing? Matt Blackman, creator of Universe & More and PhysTEC ToTY, presents his all-time favorite virtual labs, interactives and games that will leave your students begging for more physics!

Session: PS.C-SU-4 Emergent Technologies for Remote Instruction

Sunday, August 1, 12:30–1:45 p.m. Sponsors: Committee on Educational Technologies, Committee on Physics in Undergraduate Education **Presider:** *Rebecca Lindell*

PS.C-SU-4.01: Working Together, Apart, with IOLabs in Remote Introductory Physics Laboratories

Invited – Katie Ansell, University of Illinois at Urbana-Champaign

The design goal of the IOLab was to create a high-quality data acquisition tool to bring physics experiments out of the formal laboratory space and into students' daily lives. The Covid-19 pandemic has been a bittersweet outside factor to advancing this goal: Tens of thousands of students are now using IOLabs in their homes for remote introductory laboratory classes. The features of the system – particularly those that make it work for remote instruction - were developed over several years of coordination between software design, curriculum design, and assessment. The introductory laboratory classes that subsequently emerged at the University of Illinois use the IOLab as a bridge between informal investigation and formal experimentation. In this talk I will discuss how we used the IOLab's features to blend remote and classroom learning in a hybrid instruction style pre-pandemic, and how this coordination has translated to fully-remote instruction.

PS.C-SU-4.02: Using Gradescope to Administer Laboratory Exercises Remotely

Invited – Dan Young, University of North Carolina at Chapel Hill

Two of the most challenging aspects about the last year of university instruction were shifting laboratory exercises (which we call "studios") to a remote environment and admitting that grading must be done online. At UNC-Chapel Hill we have adopted the online grading system called Gradescope to both administer our studio activities and assist in the large-scale grading process of both our studios and exams. During this talk I will describe how we moved our studios to an online format deployed via Gradescope (including sharing a few sample assignments and features) along with how we take advantage of the "online assignment" mode so that students no longer submit work on paper. In addition, this talk will present various grading features and highlights in addition to describing how using Gradescope has saved us nearly 30% of grading time as compared to in-person paper grading.

PS.C-SU-4.03: Virtual Reality Enabling Remote Collaborative Physics Labs

Invited – Jared Canright, University of Washington Department of Physics

Suzanne White Brahmia, University of Washington Department of Physics

Virtual reality (VR) technology continues to mature at a rapid clip, creating potential for its use as a means of administering "hands-on" physics lab curriculum in hybrid or remote learning contexts. This talk draws from experiences administering VR-enabled labs to classes of 120 students in a hybrid model and 37 students in a remote model to inform answers to key questions around use of VR in remote labs: What advantages does VR offer over traditional "flat" simulations? Do students recognize "hands-on" work done in an immersive 3D environment as being "real" science? How is collaboration between distant students affected by use of VR? What is the current and near-future feasibility of VR technology use in remote instruction? We argue that VR labs have a niche in the remote physics lab instructor's toolbox, and outline current and anticipated applications of VR to remote physics lab instruction.

PS.C-SU-4.04: Developing Augmented Reality Modules to Teach Physics

Invited – Michele McColgan, Siena College

Nicholas Giordano, Justin Marotta, Natalie Stagnetti, Kyle Tessier, Siena College

Many undergraduate students find it difficult to visualize 3D concepts in physics and engineering courses. There is a need for context-specific spatial visualization activities to help students connect 2D representations to 3D models. We have assembled an interdisciplinary team of undergraduate physics and computer science research students and faculty to create 3D augmented reality (AR) models of physics concepts including centripetal force, torque, electric and magnetic fields and forces, and electromagnetic induction. Utilizing software including Unity, Vuforia, and Merge SDK, research students create the 3D physics models. Once developed, researchers upload the AR apps to the Apple and Android stores; making them publicly available. To use, students download the apps to their smartphone or tablet and view the Merge cube through their device, the 3D physics model appears on the Merge cube. By rotating the Merge cube, the students can view the 3D model from different perspectives.

Session: PS.C-SU-5 Ethics and Teaching in the Digital Age Sunday, August 1, 12:30–1:45 p.m.

Sponsors: Committee on Professional Concerns, Committee on Educational Technologies Presider: *Jeff Hegenbach*

PS.C-SU-5.01: The Student Experience – How to Enrich STEM Education

Contributed – Dylan Cawman, Vassar College

In physics and STEM we tend to teach in the same way across courses. The students watch the instructor solve problems, memorize the process, and regurgitate it later - all while under serious pressure to get good grades. This process can deter students from STEM, encourage cheating, and prevent deeper understanding. I wanted to find out what could contribute to a more enriched learning experience in STEM using feedback from students and teachers. By conducting surveys of students and teachers about their experiences with classes, teachers, and online tools, as well as referencing my own experience and other pedagogical resources, I set out to gain a better understanding of what makes an effective and enjoyable STEM education. I will summarize survey results and go over methods to potentially improve the learning experience such as encouraging collaboration, offering exam revisions, implementing self-grading and self-evaluations, and promoting self-motivated exploration.

PS.C-SU-5.02: Roles of Goals and Values in Ethical Discussions

Contributed – Tyler Garcia, Kansas State University

James T Laverty, Kansas State University

Researchers across scientific disciplines routinely face ethical decisions in their work, such as making data available for reproducibility. To help strengthen their ethical reasoning skills, they are encouraged to take online training programs like the CITI program or the Office of Research Integrity's "The Lab". However, it has been found that these training programs are not effective. We argue that these programs will be more effective if they are better aligned with how scientists think about their ethical decisions. Our main goal in this study is to see how scientists use goals and values in their discussions. We analyzed video data where fourteen scientists from different backgrounds met and discussed ethics in different scientific processes. In this presentation, we discuss how the scientists use their goals and values in their discussions with each other. This work can inform future ethical training to align better with how scientists address ethical situations.

PS.C-SU-5.03: Investigating How Scientists Engage in Ethical Discussions

Contributed – Bill Bridges, Kansas State University

James T Laverty, Kansas State University

Students often have no formal training in ethics. There are training sessions offered through organizations like the CITI program but there are often no courses within STEM education that offer ethical training. The purpose of this study is to investigate how scientists' values are expressed in their discussions and examine the connection between their expressed values and the situation and setting of the discussion they participate in. We analyzed video data from fourteen scientists in both group and interview settings over the span of a year. These scientists were presented with epistemic and ethical topics including reproducibility and diversity in hiring. We looked at the values invoked in their discussions, and if the invoked values were dependent on the different settings of the participants. By investigating the ways that scientists exhibit their values in their discussions we can then begin to explore how students invoke their own values.

PS.C-SU-5.04: Managing Inappropriate Online Assistance During Assessments

Contributed – Aaron Paget, Concord University

Easily available technology can tempt students to seek inappropriate assistance during assignments and exams. Several online services offer assistance in solving problems, sometimes with rapid responses. Though it is unlikely that these types of services will go away, knowing how to communicate with these services can help you to make better assessments, protect intellectual property, and verify that learners are not accessing these services during assessments. This talk outlines the options available to educators with regards to these online services.

PS.C-SU-5.05: Student Reflections: Exploring Physics, Ethics, and the Military-Industrial Complex

Contributed – Ciana Pike and Jordon Knight, Texas State University

Brianne Gutmann, Daniel Barringer, Texas State University

As current physics students, we are curious about how intertwined the military-industrial complex is with our potential futures. This question motivated our independent research study at Texas State University. We explored the intersections of ethics, academic physics, and the structure of the military-industrial complex in the United States. In this talk, we describe our motivations to participate in this research and our particular areas of interest. These include the geopolitical context surrounding emerging warfare technologies, current crossover technologies, and the interactions of stakeholders within our contemporary funding landscape. We will reflect on what we've learned and share our own personal takeaways from the project.

Session: PS.C-SU-6 Introductory Labs/Apparatus I Sunday, August 1, 12:30–1:45 p.m.

Sponsors: Committee on Apparatus, Committee on Laboratories **Presider:** *Ernest Behringer*

PS.C-SU-6.01: Integrating Bluetooth Sensors into a Web-based Lab Notebook (Pivot Interactives)

Contributed – Peter Bohacek, Henry Sibley High School

Sensors equipped with Bluetooth Low Energy (BLE) can stream data into web apps running in the Google Chrome browser. This allows students or instructors to collect data into a web-based electronic lab notebook and immediately collaborate, analyze, and provide feedback. Additionally, this means one web-based platform can provide lab instructions, data collection and analysis, lab report submission, and grading. This greatly expands the ways instructors and students can use data collected from sensors in all teaching environments. Pivot Interactives is one platform that enables this, with a growing list of compatible BLE sensors.

PS.C-SU-6.02: Computational Optics in First Year University Physics

Contributed – Duncan Carlsmith, University of Wisconsin - Madison

Experiments in optics are amenable to simulation and analysis by first year university physics students in a course including a computational environment. Many may be accomplished safely by remote students using only their mobile phones. I describe several applications including camera calibration and precise 3d location of objects using multiple mobile phone images.

PS.C-SU-6.04: Developing Leadership and Teamwork in Labs

Contributed – Nathan Powers, Brigham Young University

Robert Davis, Brigham Young University

The newly developed second year lab course at Brigham Young University was designed to incorporate explicit instruction on leadership and teamwork. Early implementations, resulted in a mixed response from students with negative responses indicating a perceived lack of alignment to the goals of a physics education. Adjustments made in subsequent semesters resulted in increased buy-in from students and indicated improved student engagement. In addition, faculty support increased. We describe the instructional strategy and feedback and suggest how the results can be used to develop a framework for preparing physics undergrads for 21st-century careers.

PS.C-SU-6.05: Complete Measurement of a Damped Harmonic Oscillation with the Smart-Cart*

Contributed – Richard Guarino, Department of Physics - Southern Methodist University

Jingbo Ye, Department of Physics - Southern Methodist University

We will present the design and performance of a complete measurement of a damped harmonic oscillation with the Pasco Smart Cart. Using the position and force sensors from the cart on a steeply inclined track (about 10 degrees from vertical), we measure the displacement, velocity, acceleration and the restoring force of the oscillator, which is the cart on the end of a spring. The students get a full understanding of these quantities in an oscillation, together with the concepts of period and frequency, both graphically, numerically and analytically. With added weights to the cart, the students can measure the spring constant in the system. By fitting to the reduction in the oscillation amplitude, the students can obtain the attenuation from friction. With one instrument, this new lab provides the students with a full range of training in harmonic oscillation. Measurement results and data analysis will be shown in the presentation.

*The lab manual will be shared with interested fellow lab instructors.

Session: PS.C-SU-7 Introducing Remote Experiments to Students Sunday, August 1, 12:30–1:45 p.m.

Sponsor: Committee on Contemporary Physics **Presider:** *Mariel Meier*

PS.C-SU-7.01: A Modern Remotely Operable Arduino Approach for Advanced Physics Laboratory

Contributed – Shawn Zaleski, RWTH Aachen University

Kerstin Hoepfner, RWTH Aachen University

Entering 2021, COVID-19 still threatens to require remote laboratory operation. New longer-term solutions need to be developed to for students to do this. Many kits have been developed for the introductory level during 2020. However, very little has been developed for the advanced physics laboratory. We have developed a kit that allows advanced lab students to perform a set of mini-experiments using basic coding and microcontrollers with compatible sensors. Students are permitted to take the kit home and perform the experiments there. The overarching goal is for students to gain familiarity with the Raspberry Pi, Arduino, and it's sensors by performing basic experiments. We give details on the different mini-experiments that the students perform. We also discuss some of the learning outcomes as well as how the experiment can easily be performed at the university or at home. We also report on student feedback.

PS.C-SU-7.02: Deployment of a Low-Cost Muon Detector as a Remote Experiment

Contributed – Gladys Velez Caicedo, Massachusetts Insitute of Technology

Andres Reyna, Sean P Robinson, Massachusetts Institute of Technology

The CosmicWatch Desktop Muon Detector is a $150 particle astrophysics apparatus for advanced laboratory students investigating sources of ionizing radiation as well as the radioactive background of their environments. The CosmicWatch triggers on muons that are the decay products originating from the charged mesons produced by high energy astrophysical particles interacting in the Earth's upper atmosphere as well as on beta and gamma-ray sources of background radiation. We will discuss cost, design, and experiments as we conducted them in our advanced physics laboratory; these could also be adapted to a high school level course. These include measuring the muon lifetime, muon angular distribution, the electromagnetic component of cosmic-ray showers, as well as using the detector as a true random number generator. We will review the hardware and software setup, the statistical analysis of detectors as well as assess the success of integration both in-person and remotely.

PS.C-SU-7.04: Remotification of Five Introductory Modern Physics labs for ~$1k apiece

Contributed – Zak Espley, University of California, Santa Barbara*

Raffi Shirinian, Deborah K Fygenson, University of California, Santa Barbara

The pandemic forced educators of instructional physics lab classes to rethink how labs are taught. We targeted introductory modern physics labs for remotification. When exploring the photo-electric effect, diffraction and interference, gamma-ray absorption, atomic spectra, and the Franck-Hertz experiment, which all involve sophisticated equipment, students engage primarily by pressing buttons, turning knobs, and reading displays. We were able to adapt and motorize classroom equipment for nearly equivalent remote engagement at relatively low cost. This was possible using consumer-grade technology that has matured over the last 15 years, namely 3D printing, single-board computers, webcams, and open-source programming libraries. In this presentation, we will demonstrate how students view and control our apparatus through a website and discuss elements and principles that have been key for successful deployment and student learning. Such remotified experiments may have post-pandemic relevance by providing students easier access to costly equipment, transcending constraints of space and time.

*Sponsor: Deborah K Fygenson

PS.C-SU-7.05: Principles of Fourier Optics in a Take Home Undergraduate Laboratory

Contributed – J. Nicholas Porter, Brigham Young University

Julio Escobedo, David A Allred, Nathan D Powers, Richard L Sandberg, Brigham Young University

As the interests of science and industry continue to push toward the very small, an understanding of advanced imaging methods has become an increasingly competitive skill for young physicists and optical engineers. However, there is a lack of undergraduate curricula that integrate concepts such as Fourier optics and coherent diffraction imaging (CDI) into their courses. We present a simple and portable experiment that allows students to explore the basic principles of Fourier optics, diffraction, digital signal processing, sampling, and coherent imaging in a take home kit.

PS.C-SU-7.06: ISLE-based Apparatus and Video Labs: Students' Beliefs about Experimental Physics

Contributed – Anna Karelina, Saint Mary's College of California

Eugenia Etkina, Rutgers Graduate School of Education

Petter Bohacek, Pivot Interactives

Matthew Vonk, University of Wisconsin River Falls

David Brookes, California State University, Chico

As part of a research project to examine whether students can develop scientific habits of mind through video-based experimentation, we created video-based Investigative Science Learning Environment learning cycles (v-ISLEs), where students investigated phenomena using interactive videos. We implemented these cycles dividing an algebra-based ISLE physics class into sections where some students used only ISLE apparatus-based labs, while some students had a mixture of v-ISLEs and apparatus labs. At the beginning and end of the semester, students answered the E-CLASS [1], a survey that assesses students' attitudes about a variety of scientific laboratory practices. We will present how the different lab settings affect students' views about their strategies and habits of mind when doing experiments.

[1] "Epistemology and expectations survey about experimental physics: Development and initial results"
Benjamin M. Zwickl, Takako Hirokawa, Noah Finkelstein, and Heather J. Lewandowski, Physical Review Special Topics - Physics Education Research, vol. 10, no. 1 (2014).

Session: PS.C-SU-8 PER: Assessment, Grading and Feedback III Sunday, August 1, 12:30–1:45 p.m.
Sponsor: Committee on Research in Physics Education Presider: *TBA*

PS.C-SU-8.01: Development of an Instrument to Assess Student Reasoning

Contributed – Brianna Santangelo, North Dakota State University

Mila Kryjevskaia, Alexey Leontyev, North Dakota State University

One of the goals of physics instruction is to help students develop reasoning skills in the context of physics. As conceptual understanding is required to reason productively, it is necessary to design an instrument that disentangles (to the degree possible) a conceptual understanding from reasoning approaches. To address this challenge, we have been developing sequences of screening-target questions: screening questions probe conceptual understanding, while target questions require students to apply this understanding in situations that present reasoning challenges. We will discuss the validation process involving cluster analysis, logistic regression, and classical test theory item analysis such as item difficulty and discrimination. Current results suggest that most items are appropriate for calculus-based introductory students and are functioning as expected.

PS.C-SU-8.02: FCI Higher Dimensions Determined by Analyzing Right and Wrong Responses

Contributed – David Pritchard, MIT

Aaron Adair, Byron Drury, Yunfei Ma, MIT

John Stewart, West Virginia University

Distractors (incorrect responses) on research-designed multiple choice instruments like the FCI reflect prevalent student misconceptions. Hence analyzing all student responses on an equal footing should yield information on actual student beliefs, whereas total score only sets a threshold for “Newtonian Thinking”. We developed a Multi-dimensional Nominal Item Response Theory that yields a “weight matrix” acting on a student’s responses to give various dimensions of ability. Analyzing 3 large colleges called State, State University, and University in order of increasing posttest score on the FCI, we find that Dimension 1 correlates with score at the 0.98 level. The weight matrix elements for the second dimension correlate at ~0.73 among these colleges and positive ability#2 represents understanding N’s 3rd but not his 2nd law vs the reverse for negative ability#2. The third dimension shows correlations of ~ 0.4 and we find that this dimension has partially different implications across the colleges.

PS.C-SU-8.03: Motivating Student Engagement in Remote Groupwork

Contributed – Karen Cummings, University of Waterloo

Richard J Epp, Meaghan E Ward, University of Waterloo

In Fall 2019 I left a small, teaching-focused school in Connecticut to join a large, research-oriented university in Canada. In Fall 2020 I helped prepare and deliver a radically different, COVID version of our introductory physics course for majors, which has enrollments exceeding 500 students and includes labs. The resulting course was amazing. We had no quizzes or exams. Instead, we incentivized engagement in remote, synchronous groupwork. Based on pre-instruction FMCE scores, students were assigned to groups of four and met twice each week to work on PER-based materials. Every third week, students did remote, modeling-oriented laboratories based on the work of Holmes and Wieman. We will describe the course and student population, including score distributions on the FMCE, an assessment of problem solving and a lab assessment. We will focus our discussion on the grading choices we made to ensure students engaged with the high-quality materials we had provided.

PS.C-SU-8.04: Effectively Implementing Peer Review into the Introductory Physics Laboratory Course

Contributed – William Poteet, Western Kentucky University - Bowling Green, KY

cott Bonham, Western Kentucky University - Bowling Green, KY

The effectiveness of peer review sessions in introductory physics laboratory courses has been measured. To implement the peer review sessions, the laboratory course has been adjusted from twelve somewhat connected experiments to three sets of experiments that all focus on a different concept within introductory physics: linear motion, springs, and collisions. The students prepare a rough draft for the paper for each set, which is then given to other students for them to critique and give feedback. An evaluation protocol to measure a given paper’s effectiveness in multiple aspects has also been developed. Comparing the results to a preliminary study completed multiple years ago, we can see the true effect that the changes to the laboratory class have made.

PS.C-SU-8.05: Using Deep Learning to Score Student Scientific Argumentation**

Contributed – Jeremy Munsell, Purdue University*

N. Sanjay Rebello, Carina M. Rebello, Purdue University

In recent years pre-trained transformer models have drastically changed the landscape of natural language processing (NLP) by achieving unprecedented performance in several domains. Among the transformer models, the Bi-directional Encoding Representations from Transformers (BERT) model reigns supreme. BERT utilizes a “self-attention” mechanism that allows it to assign importance to words in a passage and more importantly extract context and relationships between words. In this work we report on the use of BERT-like models to predict whether a student will correctly answer a quiz problem based on an essay outlining the student’s approach to solving the problem. The essay contains elements such as the system to be analyzed, the laws of physics that will be used, and how they will be applied. We compare the performance of mainstream NLP machine learning approaches (such as word count representations used with a linear model) to the use of the more sophisticated BERT-like models.

*Sponsor: Carina M. Rebello **This work is supported in part by U.S. National Science Foundation grant 1712201

PS.C-SU-8.06: Identifying Effective Practices in a Standards-based Grading System

Contributed – Colin Loxley, Western Kentucky University

Over the 2020-2021 school year we have been evaluating the use and student experience with standards-based grading (SBG) in an algebra-based physics for life sciences course. In the fall semester, I gathered student perceptions on SBG and we discovered that students were divided on how helpful they thought SBG was for learning physics. In order to evaluate effective practices in SBG; student quizzes taken over each learning objective in the class are analyzed to identify patterns of student success in a SBG system. We have also designed a survey to gauge students’ perceptions of SBG and the class. So far, the students in this class mostly have positive perceptions towards SBG for learning physics. This presentation will report on the findings of the analysis of student quizzes and student perceptions of SBG.

PS.C-SU-8.07: Transforming Collaborative Exams to Enhance Student Experience During Remote Teaching

Contributed – Andrea Jiménez Dalmaroni, Cardiff University

Collaborative exams not only can measure the learning previously gained, but also can be an optimal opportunity to produce new learning, while reducing exam anxiety. In order to enhance the student experience during assessments in remote teaching and learning, we introduced a form of collaborative exam, adding to the usual two-stage design a third stage with student self-marking. In addition, we encouraged students to become active participants in the design of the exam by incorporating student-generated content. This presentation discusses the study outcomes and the student perceptions on these exams, within the framework of an active learning intermediate-level optics course.

PS.C-SU-8.08: An Approach for Comparing Student Populations Using Item Response Curves

Contributed – Paul Walter, St. Edward's University

Ed Nuhfer, California State University (retired)

Connor Richardson, Trevor I Smith, Rowan University

Crisel Suarez, Vanderbilt University

We report on three separate cases applying a metric to compare two populations' item response curves (IRCs). Each IRC plots the percentage of students selecting a particular answer choice on an item as a function of their overall score on the concept inventory. First, we compare the IRCs of different demographic groups using data from the Science Literacy Concept Inventory. Next, we use the metric to compare American and Japanese students' IRCs used in Ishimoto, Davenport, and Wittmann (2017) for the Force and Motion Conceptual Evaluation. We also compare the IRCs of each group to the IRCs of a separate American data set. Lastly, we compare the pre-instruction IRCs to the post-instruction IRCs for a matched data set of students completing the Force Concept Inventory. The metric is a measure of the IRCs' similarity, and we used it to identify items that may exhibit bias or demonstrate differences between populations.

Session: PS.C-SU-9 PER: Student and Instructor Support & Professional Development, Program and Institutional Change II

Sunday, August 1, 12:30–1:45 p.m. Sponsor: Committee on Research in Physics Education Presider: *TBA*

PS.C-SU-9.01: Predictors of Faculty Sentiment on their Transition to Online Teaching*

Contributed – Jillian Mellen, Drexel University

Eric Brewe, Sarah Scanlin, Colin Green, Drexel University

Adrienne L. Traxler, Wright State 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, 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, sentiment scores were calculated for each response. The sentiment was found to be overall positive. Then, a machine learning model was created using Keras, which was trained on various data for 75% of the responses. The remaining 25% were used for predicting sentiment scores, to identify which data from the survey, if any, were potential predictors of participant sentiment. The score predictions were used to determine if any data on participants' institutions, positions, or transition time were correlated with positive or negative experiences.

*This project is supported by NSF DUE 2027958 and DUE 2027963.

PS.C-SU-9.02: Sentiment Analysis of Faculty Responses COVID Transition to Online Learning*

Contributed – Colin Green, Drexel University

Eric Brewe, Sarah Scanlin, Jillian Mellen, Drexel University

Adrienne Traxler, Wright State University

In response to the pandemic, colleges and universities transitioned to online learning in the spring of 2020. We investigate faculty responses regarding how undergraduate physics instruction was impacted by this transition. We received 662 responses from physics faculty. This paper focuses on an optional, open-response question about their experiences with teaching physics online. Of the 662 responses, we received 364 written responses. To investigate how faculty sentiment about online teaching changed; we used the sentiment analysis package VADER to analyze both the initial survey and a follow up survey consisting of 135 responses. The results showed a mild mean positive sentiment score both initially and in the follow up, with a potential slight increase in the positivity in the follow up survey. A repeated measures t-test resulted in a p-value of 0.14 indicating no statistically significant change in mean sentiment score.

*This project is supported by NSF DUE 2027958 and DUE 2027963.

PS.C-SU-9.03: GTAs' Use of Pedagogical Skills in Remote Mixed-reality Training Session

Contributed – Constance Doty, University of Central Florida

Ashley A Geraets, Erin K. H Saitta, Jacquelyn J Chini, University of Central Florida

Tong Wan, Westminster College

To scaffold GTAs' use of evidence-based teaching practices, we incorporated four training sessions with a mixed-reality simulator into physics GTA training during the Spring 2020 semester. Three sessions were held and facilitated in-person, while the final session was done remotely due to the COVID-19 pandemic. We decided to hold the final session remotely to balance health risks while closing the loop for GTAs' professional development and the research project. This remote style mimicked the remote teaching GTAs would do to complete the Spring 2020 semester and have continued through the Summer 2021 semester. Here, we present how two physics GTAs used the pedagogical skills during the remote training session. We also discuss implications and provide considerations for the future direction of physics GTA professional development.

PS.C-SU-9.04: Preparing Learning Assistants to Build on Students' Fruitful Physics Ideas

Contributed – Lisa Goodhew, Seattle Pacific University

Rachel E Scherr, University of Washington, Bothell

Lauren C Bauman, University of Washington, Seattle

Amy D Robertson, Seattle Pacific University

Our research team is beginning to develop instructional materials that elicit and build on common conceptual resources – ideas that may be continuous with formal physics. These materials build from students' thinking and tend to be more open-ended than research-based materials that aim to address specific difficulties. As a result, we expect that these materials like ours place different demands on instructors and that different instructional behaviors are effective in this context. While worksheets can provide a scaffolding for resources-oriented instruction, they do not in themselves respond to the complex, dynamic, and context-sensitive nature of student thinking. This talk draws on classroom video data and written teaching reflections from undergraduate Learning Assistants to begin to address the question: What kinds of preparation support new instructors in implementing resource-oriented instruction?

PS.C-SU-9.05: Interviews on Professional Development Interactions Between Experienced and Novice Teachers

Contributed – Devyn Shafer, University of Illinois at Urbana-Champaign

Maggie S. Mahmood, Tim Stelzer, Eric Kuo, Morten Lundsgaard, University of Illinois at Urbana-Champaign

Understanding how experienced and novice teachers can facilitate each other's professional development can help us to develop a supportive community of practice. In summer 2020, teachers participated in a professional development workshop as part of the Illinois Physics and Secondary Schools (IPaSS) partnership program. During the workshop, pairs of teachers discussed a set of problems focused on conceptual reasoning about energy. One pair consisted of an experienced teacher and a novice

teacher. We analyzed the dynamics of the two teachers as they established rapport and created a space where both felt comfortable sharing their ideas and expressing uncertainty. We interviewed these teachers using a video-stimulated recall technique to gain further insight into their perceptions of the interaction, and we will report the results of these interviews in this talk.

PS.C-SU-9.06: Improving Group Work in Studio-Style Physics Courses

Contributed – L Xian Wu, University of Connecticut

Matthew W Guthrie, University of Connecticut

Erin M Scanlon, University of Connecticut, Avery Point

The Department of Physics at University of Connecticut launched a studio physics program in fall 2019, to provide an engaging introductory physics education experience to thousands of undergraduate students annually. Prior to the launch, most of these introductory courses were taught using traditional lecture. A main point of tension between these two instructional modes is the role of the instructor. We noticed that instructors from a range of backgrounds experience difficulties supporting students in effectively engaging with group work. These difficulties were exacerbated when the courses were taught in a distance-based learning format. As part of a larger project to develop guides for instructors to effectively support inclusive group work, we conducted a literature review through the lenses of cognitive science, inclusive teaching, and research-based instructional strategies. In this talk, we will discuss the studio program at UConn, the findings of our literature review, and the group work guides.

PS.C.SU-9.07: Analysis of LA- and TA-Facilitated Group Work in Studio Classrooms

Contributed –Vera Degtiareva, Boston University

Emily C Allen, The Governor's Academy

Andrew G Duffy, Manher Jariwala, Boston University

Learning Assistants (LAs) are increasingly used in college physics courses all over the globe, where LAs are utilized in student-centered, active-learning environments. One of the roles of LAs is to facilitate discussions among groups of students; in this study, we investigate how LAs fulfill that role and compare them to Teaching Assistants (TAs), using a social constructivist framework. We used audio recordings from multiple studio physics classes at a large research university to develop a taxonomy to assess the level of engagement of LAs and TAs in facilitating group work. The taxonomy was then applied to our data set. We used interviews with LAs and TAs as a follow up to validate our results. We discuss our findings and compare the roles of LAs and TAs in a studio classroom environment.

Session: PS.C-SU-10 PER: Student Content Understanding, Problem-Solving and Reasoning III

Sunday, August 1, 12:30–1:45 p.m. Sponsor: Committee on Research in Physics Education Presider: *TBA*

PS.C-SU-10.01: Navigating Conceptual Uncertainties and Socio-Emotional Risks in Small-Group Work

Contributed – Muxin Zhang, University of Illinois at Urbana-Champaign

Eric Kuo, University of Illinois at Urbana-Champaign

Supporting students' sense-making in discussions and labs is an important goal of college physics instruction. In this study, we explore how students navigate the socio-emotional risks of collaboration during moments of conceptual uncertainty while doing a lab activity. Attending to sense-making in the video recording of one group's work, we contrasted two episodes where the quality of their collaboration played out differently. We found that each group member engaged in a distinct "mode" of collaboration including task-based goals, social moves, and affective states, which stayed consistent across both episodes, though certain parts of their modes were more intense during the second episode. These more intense aspects of students' contributions indicated increased risks of disagreement that potentially hindered collaborative sense-making. This study contributes another example to a body of work showing how achieving our objectives for collaborative learning depends on careful attention to students' epistemological, conceptual, and socio-emotional resources.

PS.C-SU-10.02: Supporting Student Construction of Alternative Lines of Reasoning*

Contributed – Mikayla Mays, University of Maine

MacKenzie R Stetzer, University of Maine

Beth A Lindsey, Penn State Greater Allegheny

Research in physics education has shown that poor student performance on certain physics tasks may stem primarily from domain-general reasoning phenomena rather than a lack of conceptual understanding. The observed reasoning patterns are consistent with dual-process theories of reasoning (DPToR). Efforts are ongoing to design strategies to guide the development of research-based curriculum to help students strengthen their reasoning skills and support cognitive reflection. In one intervention focused on supporting analytical processing, students are asked to set aside their own reasoning and engage in alternative lines of reasoning. Students first respond to a qualitative physics task, then construct reasoning chains in support of answers given by fictitious students, and finally revisit the original physics task. In this talk, we will discuss intervention results in the context of kinematics, examine factors possibly related to its effectiveness, and highlight the implications of our findings for future DPToR-aligned curriculum development.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

PS.C-SU-10.03: Supporting Students in Exploring Alternative Lines of Reasoning*

Contributed – Thomas Fitts, University of Maine

MacKenzie R Stetzer, University of Maine

Mila Kryjevskaia, North Dakota State University

An emerging body of research suggests that the nature of human reasoning itself may impact student performance on physics questions. Analysis of student reasoning patterns through the lens of dual-process theories of reasoning (DPToR) indicates that students may struggle to engage analytical processing productively when responding to physics questions containing salient distracting features (SDFs). While students may reason correctly on one question (screening question), they may abandon that same line of reasoning on an analogous question containing an SDF (target question). As part of a larger effort to investigate and support student reasoning in physics, we have designed and tested an intervention that explicitly guides students to apply the reasoning they successfully used on the screening question to the target question in order to help students reconsider their default responses. In this talk, preliminary results will be presented and implications for research-based curriculum development will be discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, and DUE-1821561.

PS.C-SU-10.05: Shared Resources in Student Problem-Solving of Spherical Unit Vectors: Example

Contributed – Brant Hinrichs, Drury University

Ying Cao, Drury University

We are interested in understanding different ways that students collaborate to solve physics problems. One mechanism we have recently observed in the context of spherical unit vectors in upper-division E&M, is that students first co-construct a visual representation, which we call a shared resource, that they then use to solve the problem. The previous talk introduced and elaborated on the theoretical framework of shared resources. In this companion talk, we go into greater detail about how the previously identified shared resource helped two students navigate through some of the difficulties of a challenging problem. In particular we illustrate how the shared resource externalized and coordinated bits of productive thinking that each student brought to the collaboration. We conclude with some implications for possible instructional strategies.

PS.C-SU-10.06: Shared Resources in Student Problem-Solving of Spherical Unit Vectors: Theory, Methodology

Contributed – Ying Cao, Drury University

Brant Hinrichs, Drury University

We are interested in understanding the different ways that students collaborate to solve physics problems. One mechanism we have recently observed in the context of spherical unit vectors in upper-division E&M, is that students first co-construct a visual representation, which we call a shared resource, that they then use to solve the problem. While the resources framework as applied in physics education has usually focused on the thinking of individuals, in this work we expand it to look at that of a small group instead. In this first of two related talks, using data from a think-out-loud interview, we illustrate what we mean by the theoretical lens of shared resources: what they are, how they are shared, and what role they can play in helping students make sense of a difficult physics topic. We also describe how we identified a particular shared resource by analyzing student writing, utterances, and behavior.

PS.C-SU-10.08: Implications of Module Analysis for Instruction of One-Dimensional Vector Manipulation

Contributed – Nekeisha Johnson, North Dakota State University

John B. Buncher, North Dakota State University

It has been extensively documented that introductory physics students tend to struggle with adding and subtracting vectors. The results of a multiple-choice assessment, given to students in large-enrollment, algebra-based courses, were analyzed to identify groups of incorrect responses that were commonly given together. Following the analysis using both module analysis and modified module analysis, the stability of the groups over multiple semesters was examined, and yielded modules of responses that were most closely linked together. These modules were compared across the two analysis methods and classified to identify the underlying mistakes. We now present implications for classroom applications, including the relative prevalence of each kind of mistake, as well as the identification of modules with a high number of contributions per student and modules with the highest number of students contributing.

Session: PS.C-SU-11 Physics Experiences of Students from Underrepresented Groups

Sunday, August 1, 12:30–1:45 p.m. Sponsor: Committee on Research in Physics Education Presider: *Eric Kuo*

PS.C-SU-11.01: LGBT+ Physicist: Rethinking Methodology and Building Situated Knowledge

Invited – Ramon Barthelemy, University of Utah

This talk will explore the creation of the LGBT+ physicists and how it launched a movement that created an American Physical Society ad-hoc committee and research project that changed policy for LGBT physicists nationwide. Results indicated the importance of climate and demonstrated gendered differences in experiences of harassment across LGBT persons. Differential levels of outness were also observed for People of Color. The research was done using a non-comparative framework where knowledge was constructed from the lives of LGBT+ physicists without comparisons to non-LGBT+ peers.

PS.C-SU-11.02: Networks of Support for Minoritized Students in Physics

Invited – Allison Gonsalves, McGill University

This presentation details the potential that counterspaces—safe spaces for minoritized groups in physics—have to support students' persistence in physics. Focussing on undergraduate and graduate learning environments, I describe attributes of a counterspace for minoritized students in physics, and the positive identity resources (relational, ideational and material) students access through it. I will discuss the usefulness of Social Network Analysis to facilitate our understanding of how resources flow through networked relationships established in these spaces, and the affordances and constraints of institutionally-supported counterspaces in physics.

PS.C-SU-11.03: Identity Performances of Multiply Marginalized Physics Students at HSIs*

Invited – Xandria Quichocho, Michigan State University & Texas State University

Eleanor W. Close, Texas State University

Investigations on physics identity development are critical to student retention in physics degree programs. However, identity studies in physics education research have typically been conducted at Predominately White Institutions on physics students, without focus on the intersections between gender, sexuality, or race. The studies that investigate social identities tend to generalize the experiences of "underrepresented minority students," which leads to an erasure of many other students who still exist in the margins. We invite multiply marginalized physics students—women of color, and LGBTQ+ women, including transgender women and other gender minorities—to participate in semi-structured interviews about their unique experiences in physics. All students studied at Hispanic-Serving Institutions and were asked about their perceptions of their physics environments, available support systems, and how they would describe a physicist. The analysis examines the narratives using intersectionality and critical race theory to fully understand the extraordinary lived experiences of our participants.

*This work has been supported in part by NSF grants DUE- 1557405, DUE-1557276, DUE-1431578, and PHY-0808790.

PS.C-SU-11.03: Physics Experiences of Students from Underrepresented Groups

Invited – Simone Hyater-Adams

Session: PS.C-SU-12 Teaching Online/Remote Physics Classes
Sunday, August 1, 12:30–1:45 p.m. Sponsor: Committee on Research in Physics Education Presider: *Tengiz Bibilashvili*

PS.C-SU-12.01: Mad – Not So Mad Scientist

Contributed – Sanjay Dey, Oberoi International school

I love physics. It can be as simple as F=mg to as complicated as $F=GMm/r^2$. The more I learned, the more I realised there is so much more to it. I took my curiosity around the world digitally through social media. Research question:- How experiments were done in the unconventional scientific environment affect the viewer's curiosity to engage. The methodology:-Measure difference in viewer's curiosity to engage in unconventional and conventional scientific experiments with counts of likes, comments and views from social media platforms. More, views, likes and comments were accepted to be directly correlated to viewers curiosity to engage in the video. The purpose of the study was to explore the relationship between unconventional scientific environment and the viewer's curiosity to engage. Results showed that the newer unconventional environment instead of being in a conventional lab setup had a positive effect on viewers to keep them curious on the topic.

PS.C-SU-12.02: Informal Science for High School Students Over Video Conference

Contributed – Hank Yochum, The Citadel Kaelyn D. Leake, The Citadel

We will discuss our approach to presenting physics as a relevant and engaging discipline to high school students with the constraint of not having participants on our campus. For our outreach program, our goal is to have students build, test, and troubleshoot projects that increase their confidence, present physics as an applied subject, and of course increase their interest in physics. The lack of in-person events makes fulfilling the hands-on element a particular challenge. We designed and implemented two Saturday physics experiences for high school students. Components for the projects were mailed to participants. One benefit to this approach over in-person events was that participants “attended” the event from locations far from our campus. We will discuss design considerations for doing outreach over video conference and the activities we developed.

PS.C-SU-12.05: Using Standards-based Grading in an Online Physics Course

Contributed – Timothy Duman, University of Indianapolis

In a traditional classroom, the student’s learning is assessed by using three or four exams in a given semester. With standards based grading, the learning is broken down into smaller more manageable learning objectives. Students can be assessed on these learning objectives at multiple different times throughout the semester. As a student understand improves, their grade also improves. Older assessments have less weight in determining a student’s grade. This presentation will discuss success, challenges, and software used to implement standard based grading in an introductory physics course.

PS.C-SU-12.06: The Effectiveness of Online Education for Introductory Astronomy

Contributed – Joseph Gallagher, University of Cincinnati Blue Ash College

Many problems that we face in our society today can only be adequately understood, let alone solved, with an understanding of science (eg. Miller, 1998). Whether in the areas of health care, foreign policy, education, etc., a grasp and an appreciation of science and the scientific method will be critical tools for progress. It is therefore incumbent upon those in higher education to improve the quality and quantity of STEM offerings and to champion the importance of science to the community at large.Nearly 250,000 students take introductory astronomy annually, most of whom are non-science majors. These students are our future lawyers, business owners, politicians, journalists, and perhaps most importantly, teachers. This presentation will highlight the efforts at UC Blue Ash to expand our introductory astronomy offerings using an online format, while simultaneously assessing efficacy through a qualitative and quantitative comparison to a face-to-face course with similar content and assessments.

PS.C-SU-12.07: Interventions Designed to Help Students Recognize and Overcome Reasoning Inconsistencies*

Contributed – Kristin Kellar, University of Washington

Paula Heron, University of Washington

Dual Process Theories of Reasoning suggest that humans reason using System 1 (heuristic) and System 2 (analytic) thinking processes. This research seeks to develop interventions that help introductory undergraduate physics students recognize reasoning inconsistencies and activate System 2 thinking effectively to override initial incorrect responses. In a prior study (Kryjevskaia et al., 2014), screening and target questions aimed to identify students with relevant content knowledge who nevertheless relied on System 1 thinking when answering the target question. In the current study, “intervention” and “consistency” questions were added with the intent of alerting students to their reasoning inconsistencies. Students who indicated that their answers were inconsistent were presented with another opportunity to answer the target question. Kryjevskaia, M., Stetzer, M. R., & Grosz, N. (2014). Physical Review Special Topics - Physics Education Research, 10(2), 1–12. https://doi.org/10.1103/PhysRevST-PER.10.020109 *This study is supported by the National Science Foundation under Grant No. DUE 615418.

Session: PS.C-SU-13 Physics & Astronomy SEA Change Efforts **Sunday, August 1, 12:30–1:45 p.m.**
Sponsors: Committee on Diversity in Physics, Committee on Women in Physics Presider: *David Marasco*

PS.C-SU-13.01: Physics & Astronomy SEA Change Efforts

Invited – AAPT, AIP

AIP has supported the P/A pilot through the AIP Venture Partnership Fund.

PS.C-SU-13.02: Physics and Astronomy SEA Change Pilot Progress

Invited – Alexis Knaub, AAPT

The first set of Physics and Astronomy departments have started the SEA Change process. Alexis Knaub will discuss the progress of the pilot program thus far, including lessons learned from experience and potential lessons from preliminary research on the AAAS institutional Bronze awardees.

PS.C-SU-13.03: Physics & Astronomy SEA Change Overview and History

Invited – Beth Cunningham, American Association of Physics Teachers

For the past several years, leadership from the Physics and Astronomy disciplinary societies have been working with AAAS to launch the SEA Change Project in our fields, specifically Physics and Astronomy departments. Beth Cunningham will provide an overview of the Physics/Astronomy disciplinary committee and outline its history, including how members of Physics and Astronomy have influenced the AAAS Disciplinary Awards.

PS.C-SU1-13.04: The Origins of SEA Change

Invited – Shirley Malcom, AAAS

In 2017 AAAS created the STEMM Equity Achievement Project (SEA Change). The aim is to support and recognize post-secondary institutions and departments as they address structural changes to advance equity, diversity, and inclusion. Shirley Malcom will describe the development of the SEA Change project, including the need for the disciplinary awards.

PS.D-SU-1.01: Creating Virtual Reality STEM Escape Rooms

Contributed – Eric Bubar, Marymount University

The use of games in the classroom is an excellent pedagogical tool to improve student engagement, enjoyment and mastery of course material. The recent advent of low-cost, standalone virtual reality headsets in particular offers the opportunity for educators to create highly immersive and engaging learning experiences. The so-called MDA (Mechanics, Dynamics, Aesthetics) framework from game design theory, provides an excellent framework for developing these new forms of educational opportunities. This work will discuss the use of the open source Unity physics game engine along with the C# scripting language and low-cost commercial game assets to create a STEM themed virtual reality escape room for the tetherless Oculus Quest 1/2 VR headsets. In addition, recommended workflows and design methodologies will be presented.

PS.D-SU-1.02: Using a Capstone Experience in the Introductory Physics Classes

Contributed – Tatiana Krivosheev, Clayton State University

Dmitriy Beznosko, Clayton State University

We present our attempt 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 addition of a capstone project is introduced as a part of the general course redesign funded by the Affordable Learning Georgia grant.

PS.D-SU-1.03: Beyond the Visual: Multimodal Design of Physics Interactive Simulations

Contributed – Brett Fiedler, University of Colorado at Boulder

Emily B Moore, University of Colorado at Boulder

Humans think and communicate using auditory, gestural, and visual information to co-create and convey meaning. Notably, learning can be more effective with multimodal input and feedback such that complimentary cognitive resources can be accessed. For technology-enhanced learning, this means that expanding learner input – what learners actively do – and feedback could bring about novel learning opportunities and advance inclusive learning. In this work, we design and investigate multimodal STEM interactive simulations that are inclusive to learners with and without sensory and/or learning disabilities. Through interviews with K-12 and university students with and without visual impairments or learning disabilities using PhET Interactive simulations, we investigate how learners utilize the various input and feedback modalities for PhET sims, how learners ground their mathematics and science learning through bodily movement, and how the range of input and feedback modalities PhET sims afford can support learners to engage in collaborative learning tasks together.

PS.D-SU-1.04: Swarmnotes for Live Collaborate Note-taking: Logistics and Uses

Contributed – Bradley McCoy, Azusa Pacific University

Sarah Petry, Nate Tamminga, Brianna Christiansen, Azusa Pacific University

Swarmnotes is a new strategy for note-taking and coaching in an online classroom environment, in which students and the instructor collaboratively edit an online whiteboard. In this talk, we will demonstrate the logistics of Swarmnotes and demonstrate several uses of this flexible tool including Peer Instruction with multiple-choice, open-ended, or draw-a-diagram formats; handouts with gaps; derivations in which students take turns doing the next step; and notating-the-notes during and after class.

PS.D-SU-1.05: Swarmnotes for Live Collaborate Note-taking: Student Perspectives

Contributed – Sarah Petry, Azusa Pacific University*

Bradley K McCoy, Brianna Christensen, Nate Tamminga, Azusa Pacific University

Swarmnotes is a new strategy for collaborative note-taking in an online environment. In this talk, we present student perspectives on the benefits of Swarmnotes from interviews of all students in a small Quantum Mechanics class. Swarmnotes has had a dramatic impact on the way students learn and take notes. It ensures strong conceptual understanding in which misconceptions have a remarkably short lifespan, through the availability of immediate correction from peers and the instructor, made less threatening by the collaborative process. Edit access for all class members allows each individual student to contribute to and benefit from the insights of the entire group during and after class. This method also builds skills in teamwork as students observe and coach each other as they learn.

*Sponsor: Bradley McCoy

PS.D-SU-1.06: Customizing Student Experiences by Pushing Randomized Values to Simulations

Contributed – Matthew Vonk, University of Wisconsin River Falls and Pivot Interactives

Peter H Bohacek, ISD 197 and Pivot Interactives

Computer simulations can provide an efficient and low-stakes way for students to discover and apply scientific principles. However, until recently it has been difficult to customize simulation parameters for particular students so that each student is exploring a virtual space that is unique to them. Such customization can make the exploration more authentic and may discourage direct copying of other students' work. The arrival of PhET-IO allows not only this type of customization, but also allows autograded questions based on each set of unique parameters.

PS.D-SU-1.07: Teaching Assistants' High Impact Social Practices in Remote Physics Recitations

Contributed – Joe Olsen, Rutgers, The State University of New Jersey

Nicolette Maggiore, Rutgers, The State University of New Jersey

Debbie S. Andres, Paramus High School, NJ

Charles Ruggieri, Rutgers, The State University of New Jersey

Due to COVID-19, remote physics instruction has become ubiquitous. This research examines which practices are highly impactful for creating social connections between teaching assistants and students in synchronous remote settings. We recorded interactions between students and teaching assistants in introductory physics active learning problem solving sessions and coded teaching assistant behaviors for types of social practices (e.g., addressing students by name or expressing empathy about course workload). By administering a validated survey of social alignment [1] to students at the end of their recorded sessions, we were able to determine which practices were most impactful to students' feelings of social connection with their instructors. The results of this study have implications for training teaching assistants in facilitating remote problem-solving sessions.

[1] Adapted from Schmidt, H. G., Moust, J. H. (1995) What makes a tutor effective? A structural equations modeling approach to learning in problem-based curricula. Academic Medicine, 70(8),708-714.

Session: PS.D-SU-2 Introductory Courses I

Sunday, August 1, 2–3:15 p.m. Sponsor: AAPT Presider: *TBA*

PS.D-SU-2.01: Equipotentials-Matching Challenge: An Alternative to the Classic Plotting Lab

Contributed – Richard Zajac, Kansas State University Polytechnic

A classic lab activity for electrostatics involves mapping out 2-D equipotentials on semi-conductive paper, allowing students to visualize the shapes of electric field and potentials. But what can be done for distance students or students who cannot attend a hands-on lab? To address this, we developed a graph-matching challenge in which students must lay out charges to produce a desired field and/or potential. The simulation activity runs entirely in Excel and features 3-D surface plots that are visually more stunning than the flat line drawings proposed in most textbooks, and arguably more evocative than the deliverables produced in the traditional lab. We discuss technical details, student feedback, and the results of follow-up assessments.

PS.D-SU-2.02: Developing Critical Thinking Questions for Introductory Physics Courses

Contributed – Blane Baker, William Jewell College

Part of our mission at a liberal-arts college is to provide students with educational experiences that prepare them for citizenry in the 21st century. One of the essential skills of modern-day graduates is critical thinking. The study of physics provides an ideal test bed for developing critical thinking, given the discipline's wide applicability and relevance in the world. This talk will discuss how to create critical thinking questions and how to develop students' critical thinking skills. We will focus on qualitative questions that may or may not involve numerical arguments. Example questions will be taken from ones developed for introductory physics which include topics in mechanics, waves and sound, thermodynamics, electricity and magnetism, and optics. We will consider how to use a simple rubric to evaluate students' answers. Grading is similar to scoring numerical problems and thus less cumbersome than expected.

PS.D-SU-2.03: Video-based Graphical Analysis Homework Problems

Contributed – Author: Cindy Schwarz, Vassar College

Ben Brady, Vassar College

This is a follow up on a paper presented during the summer 2020 virtual meeting. We have now completed 20 problems integrated into the expert TA system as the Physics Video Analysis Collection. Students in my introductory classes in fall 2020 solved these problems as part of their homework assignments. I also had a student from that class look at all the problems and we have and new hints and feedback, common wrong answers identified as suggested from the student perspective have been added. These changes have improved on what was already an excellent pedagogical experience. I will show them in the expert TA system, focusing on pedagogy not available in more traditional problems and I will also report on student experiences in learning from them.

PS.D-SU-2.04: Teaching Electric Field Before Coulomb's Law

Contributed – Paul Emigh, Oregon State University

Alfred DeAngelis, Brenden K Greenwood, Jonathan W Alfson, Oregon State University

The electric field is one of the more abstract concepts taught in introductory physics. Introductory E&M courses often start by introducing Coulomb's Law—an expression for the force between two point charges—before eventually defining the electric field as a ratio of the electric force to the charge on a "test charge". This definition can result in some confusion among students; for example, students often have difficulty with the idea that the electric field is independent of the "test charge". We decided to switch the order in which these topics are taught in a calculus-based introductory physics course: first introducing the electric field as the cause of electric forces, and later introducing the electric field caused by a point charge. We will share some pedagogical affordances of beginning E&M in this fashion as well as some observations from our initial implementation.

PS.D-SU-2.05: Solving Kinematics Problems Using Kinematic Graphs

Contributed – Calvin Berggren, Texas Lutheran University

Kinematic graphs is a popular topic for algebra-based physics, but rarely are the graphs used to solve problems. This talk will communicate experience I have gained in how to teach students to solve kinematics problems directly from the graphs.

PS.D-SU-2.06: Using Introductory Physics to Model Motion of Respiratory Aerosol Droplets

Contributed – Jonathan Bennett, North Carolina School of Science and Mathematics

Airborne droplets emitted from the mouth during coughing, sneezing and breathing provide the main pathway for transmission of respiratory diseases such as COVID-19. We show how classical mechanics (Newton's Laws) and fluid mechanics concepts (drag force, buoyancy, Reynolds number) can be applied in some simple models to help students understand the motion of aerosols emitted during respiratory events. The results illuminate why aerosols can remain in the air for long times and travel for surprisingly long distances. For those interested in further exploring the physics of respiratory aerosols, we provide links to some recent journal articles and to a computational model by Bazant et al. of risks of respiratory infection in indoor areas with variable ventilation, number of occupants and human behaviors (breathing rates, mask wearing compliance etc.)

Session: PS.D-SU-3 Introductory Labs/Apparatus II

Sunday, August 1, 2–3:15 p.m. Sponsors: Committee on Laboratories, Committee on Apparatus Presider: *TBA*

PS.D-SU-3.01: An Apparatus for the Lab of Uniform Circular Motion

Contributed – Jingbo Ye, Department of Physics/Southern Methodist University

Richard Guarino, Department of Physics/Southern Methodist University

Uniform Circular Motion (UCM) is discussed in college physics. A lab that is commonly used to demonstrate the relationship between the centripetal force and the angular velocity usually involves a string. The string that connects the rotating object to a weight or a force sensor is turned 90 degrees by a pulley. This scheme has the problem that the string will twist and the pulley has friction. Utilizing the force and gyro sensors in a Pasco Force Sensor and with a custom rotor, we constructed a UCM lab with precision measurement results. A photogate is used to double check the angular velocity measured by the gyro sensor. This double measurement of the same quantity provides students with an example and training of calibration and cross-check in scientific work. We will present the design and performance of this lab, and share the lab manual with interested fellow lab instructors.

PS.D-SU-3.02: Practices and Concepts in Physics Labs: Can We Do Both?

Contr ibuted – Jason May, University of Utah

Lauren Barth-Cohen, Adrian Adams, University of Utah

Many newly reformed introductory physics laboratory courses prioritize student engagement with scientific practices, in line with a significant body of PER research that suggests these courses often do not adequately enhance students' conceptual knowledge. However, is it possible for introductory physics labs to focus on student engagement with scientific practices AND the generation of conceptual knowledge simultaneously? In this presentation, I discuss how our Introductory Physics for Life Sciences (IPLS) lab instructional team refined existing evidence-based instructional strategies and curricular activities to elicit students' simultaneous engagement in scientific practices and the generation and utilization of new conceptual knowledge during investigations. We show how these refinements resulted in students collaboratively generating conceptual mechanistic knowledge of complex biophysical systems and using this knowledge in open-ended experiments to build scientific models of related scientific phenomena. These examples provide evidence that physics lab courses can engage students with scientific practices and conceptual learning simultaneously.

PS.D-SU-3.03: Measuring the Added Mass of a Falling Coffee Filter

Contributed – James Pantaleone, University of Alaska Anchorage

The acceleration of a falling coffee filter released from rest is always much less than the free-fall acceleration of gravity, g. This is true even near the initial release, when the part of the drag force proportional to the velocity is negligible. This small acceleration occurs because there is a part of the drag force that is proportional to the acceleration. This part is called the added mass. The added mass is a large effect for falling coffee filters. Nesting the coffee filters does not change the added mass. The measured value of the added mass from the initial acceleration agrees with the theoretical value calculated for an ideal fluid. In experiments using a motion sensor or video analysis, it is easy to simultaneously measure both the added mass and the steady-state drag force.

PS.D-SU-3.04: Student Perception of Engineering Design Activities in Introductory Physics Labs*

Contributed – Jason Morphew, Purdue University

Amir Bralin, Thomas Chapman, Carina M. Rebello, N. Sanjay Rebello, Purdue University

Integration of engineering design activities in physics has been shown to be effective in improving student achievement, attitudes, and learning in K-12 settings. Prior research supports the idea that engineering design activities have the potential to bring value to a physics course and to facilitate transfer between engineering courses and physics. During the Spring 2021 semester we introduced an engineering design challenge, to design a simplified Martian lander, in the introductory physics labs midway through the semester. Using surveys, we examined student interest, metacognition, and transfer. Our preliminary results suggest that most students were able to make connections to other classes and their majors. Students also reported using metacognitive monitoring and control strategies during the design project. However, student perceptions of the workload limited student interest. Implications for implementation of engineering design activities will be discussed.

*Supported in part by U.S. National Science Foundation grant 2021389

PS.D-SU-3.05: Martian Lander: Integrating Engineering Design into Undergraduate Introductory Physics*

Contributed – Thomas Chapman, Purdue University

Amir Bralin, Jason W Morphew, Carina M Rebello, N. Sanjay Rebello, Purdue University

Problem-solving skills are critical in the 21st century workforce. For example, engineers and scientists often must solve complex, ill-defined problems. In contrast, many introductory undergraduate science courses focus on simple, well-defined problems. While engineering majors learn design practices in their first-year engineering courses, engineering design is not addressed in other science courses. Students may not see the relevance of science to the practices of engineering design. This project aims to develop, implement, and evaluate a strategy that integrates engineering design into the laboratory experiences in undergraduate introductory calculus-based physics. In this talk we describe how we designed a lesson that integrates principles of mechanics with engineering practices to design a Martian Lander. We will share our experiences from designing and implementing materials. Finally, we will discuss the implications for designing physics curricula that integrates the learning of physics with engineering design.

*This work supported in part by U.S. National Science Foundation grant 2021389.

PS.D-SU-3.06: Graduate TA Perceptions of Engineering Design in Introductory Physics Labs*

Contributed – Amir Bralin, Purdue University

Thomas Chapman, Jason W. Morphew, Carina M. Rebello, N. Sanjay S Rebello, Purdue University

Efficacy of any educational intervention is dependent upon the educators' knowledge of pedagogy, goals, strategies, and students' learning. After the implementation of a Martian Lander engineering design challenge in our introductory undergraduate course for future engineers, we conducted a focus group interview with the graduate TAs about their impressions of the implementation of the unit. None of the TAs had any prior experiences with engineering design. When asked about their perceptions of the value of the design challenge and its role in a physics class, TAs expressed a wide spectrum of views. However, there was overarching consensus that the ill-structured nature of the challenge left many students and some TAs unclear about their expectations for success. We will present the results of the focus group interview and describe our plans for changes in the engineering design challenge implementation in future semesters.

*This work is supported in part by U.S. National Science Foundation grant 2021389.

PS.D-SU-3.07: Analysis and Simulation of the Non-circular Fringe in Michelson Interference

Contributed – Xiaohong Zhao, Science School, Beijing University of Posts and Telecommunications,

Michelson interference experiment is a basic experiment in college physics. In the experiment of equal inclination interference with point light source, occasionally, students observed the elliptical and hyperbolic curve interference fringes rather than circular fringes. The reason of this abnormal phenomenon was analyzed theoretically with the method of equivalent virtual point light source. When the two mirrors are not strictly perpendicular, the elliptical or hyperbolic curve interference fringes can be observed. The optical path of the two virtual points on the viewing screen was calculated whether the two mirrors were perpendicular to each other and the interference fringes were simulated. The theoretical analysis and simulation results are in agreement with the experimental phenomena. Finally, we proposed how to avoid abnormal phenomena.

Session: PS.D-SU-4 Learning from Other Disciplines Related to PER

Sunday, August 1, 2–3:15 p.m. Sponsor: Committee on Research in Physics Education Presider: *Rebecca Lindell*

PS.D-SU-4.01: "It was Never Mechanically Explained": Membrane Potentials in Physiology

Invited – Matthew Lira, University of Iowa

In 2002, Donald Rumsfeld famously spoke of "unknown unknowns" when questioned about weapons of mass destruction in Iraq. Though the language was tortuous, philosophers now acknowledge the validity of his analysis. Rumsfeld's Knowledge Quadrants—as I will call them—offer an analytic tool for the Learning Science and STEM education researchers concerned with students' epistemic cognition. When students recognize a known unknown, students are "ready-to-learn". Drawing upon experimental work in cognitive science and clinical interviews in biology education research, I illustrate how combining multi-modal analyses of students' drawings, speech, and gestures provide insight into their epistemic gaps (i.e., known unknowns). Using an illustrative case study, I demonstrate (1) how to detect epistemic gaps and (2) how gesture provides a mechanism for resolving them. These insights from the Learning Sciences point to broader problems concerning how we teach for interdisciplinary coherence at the intersection of physics and biology.

PS.D-SU-4.03: Beyond Linear Regression: Analyzing Common Data Types in DBER

Invited – Elli Theobald, University of Washington

Discipline based education research often compares student outcomes (e.g., performance, affect) across treatments. These quasi-random experimental designs can entail students in section A experiencing a treatment and students in section B experiencing a control. However, if the differences between students are not accounted for, student-non-equivalence can confound results or mask true treatment effects. Linear regression is one way to control for student non-equivalences that arise from quasi-random designs. However, linear regression only works for continuous outcome data that meet certain assumptions. As DBER research has become more sophisticated and researchers measure more nuanced student outcomes, statistical analyses must extend beyond linear regression. Here I will review extensions of the linear regression model – generalized linear models (glms) – and compare seven glm types. By the end of the session, participants will be able to articulate why controlling for confounding variables is critical and identify when to apply different glm methods.

PS.D-SU-4.04: Due Respect: Using Existing Standards for Instrument Development

Invited – Jennifer Lewis, University of South Florida

As DBER gains in stature, results of DBER studies are being used to make decisions. While we should celebrate the move toward evidence-based decision-making, high quality decisions require high quality data. Creating an instrument that will lead to valid and reliable inferences is a difficult task that is typically attempted only if no existing instrument is suitable; however, researchers who want to avoid the challenges of instrument creation still need a basis for making decisions regarding the quality of existing instruments. Using a framework to examine available psychometric evidence during the instrument selection process can help researchers to determine whether an instrument is likely to yield score interpretations that will support sound decisions.

Session: PS.D-SU-5 PER: Curriculum and Instruction I

Sunday, August 1, 2–3:15 p.m. Sponsor: AAPT Presider: *TBA*

PS.D-SU-5.01: Student Perceptions of Computation after Upper-Level Coursework

Contributed – W. Brian Lane, University of North Florida

Cortney Headley, University of North Florida

Anecdotally, it seems that many physics students are surprised when they first encounter computation in a physics curriculum, leading us to wonder how students perceive computation as a physics activity. Do they see computation as a helpful practice that is normative within the physics research community, or do they see it as a niche activity? Do they confidently look for opportunities to use computation in their coursework and research, or do they prefer to avoid engaging with computation? To what degree do they expect to use computation in their careers? We investigated these questions by interviewing 4 undergraduate physics majors in the semester after they encountered significant computational work in a set of upper-level physics courses. For most of these students, these courses presented their first encounter with computation in a physics context. These interviews revealed overall positive perceptions of computation and appreciation for a variety of computational applications.

PS.D-SU-5.02: Using Clicker Question Sequence to Teach Time-Development in Quantum Mechanics

Contributed – Peter Hu, University of Pittsburgh

Yangqiuting Li, 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. We thank the National Science Foundation for support.

PS.D-SU-5.03: The Interdependence of Physics Self-Efficacy and Calculus Transfer Ability

Contributed – Christopher Fischer, University of Kansas

Jennifer A Delgado, University of Kansas

We present the initial validation of an assessment of calculus proficiency in the context of introductory physics (i.e., calculus transfer to physics), including how calculus proficiency and mathematics self-efficacy affect physics self-efficacy, and how these attributes intersect with student identity (e.g., gender and ethnicity). Although preliminary, these results nevertheless indicate how using separate instruments for assessing physics self-efficacy and calculus transfer in tandem can support data-guided curriculum modifications to improve calculus transfer to physics, improve physics self-efficacy, or both simultaneously. Due to the prevalence of physics courses in many STEM degree programs, such instructional changes have the potential to improve student performance and retention in many disciplines, including among groups traditionally underrepresented in STEM.

PS.D-SU-5.04: Instructors' Impact on Students' Perceptions of Computation

Contributed – Cortney Headley, cortneyheadley2000@gmail.com

Brian Lane, University of North Florida

In recent years, computation has emerged as a key instructional tool in physics alongside experiment and analytical problem-solving. In this evolving pedagogical practice, the ways in which instructors influence their students' perceptions of computation is not well understood. Based in a communities of practice framework, this study aims to identify connections between students' perceptions of computation in physics and their instructors' perceptions. We interviewed physics majors and their instructors after they completed a set of computation-infused physics courses about their uses of computation in physics. The results will examine the degree to which these students' perceptions of computation were influenced by their instructors. From these themes, we draw recommendations to enhance the integration of computation into undergraduate physics courses.

PS.D-SU-5.05: Impact of Extra Credit on Students' Cramming Behavior

Contributed – Zachary Felker, University of Central Florida

Zhongzhou Chen, University of Central Florida

Our earlier study suggested that offering a small amount of extra credit can encourage better work distribution and reduce procrastination among college students completing online introductory physics homework assignments. The current study focuses on measuring the "cramming" behavior among students who complete most assignments close to the due date. Based on an agglomerative clustering algorithm, we identified sub-populations of students who completed assignments either against the assignment due date, or against the earlier extra credit due date. We found that those who completed the assignments near the due date are more likely to display behavior and outcomes typically associated with "cramming". Those include higher homework failure rate, shorter time on task, and lower exam scores. In contrast, those who completed the assignments against extra credit due dates have significantly higher exam scores and lower rates of module failure.

PS.D-SU-5.06: Incorporating Computational Activities in a General Education Astronomy Course

Contributed – Raymond Zich, Illinois State University

James DiCaro, Andrew Princer, Illinois State University

We report on the impact of an instructional intervention incorporating computational activities into a one semester general astronomy course. Computation is an effective active learning tool for developing understanding of concepts, connecting concepts with formulae, and associating science with prediction. Spreadsheet-based computational exercises were included in the course and completed collaboratively, along with other active learning activities. The results of inclusion of the computational exercises are presented, along with examples of the computational exercises. The reasons for introducing computational activities will be discussed, along with benefits supporting the inclusion and difficulties faced when implementing the change. Student learning pre to post was measured with the TOAST and LPCI, and qualitative data was collected in the form of student surveys to investigate student learning, attitudes toward computational exercises, and overall perceptions of the course. Student surveys revealed an overall positive attitude toward the addition of computational activities.

PS.D-SU-5.07: The Social Negotiation of Confusion for Physics Learning

Contributed – Alli Pfohl, Western Washington University

Thanh Le, Andrew Boudreaux, Carolina Alvarado, Jayson Nissen, California State University Chico

Collaborative learning is increasingly common in physics education. At Western Washington University and Chico State, we are examining student management of confusion during small group activities, with a focus on the relationship between emotions and student engagement in tasks explicitly designed to trigger confusion. A primary context for our research is the Next Generation Physical Science and Everyday Thinking curriculum. We will use four types of data: written reflections, classroom video, interviews, and experience sampling method (ESM) surveys. ESM is an in-the-moment survey that asks participants to report their affective experiences. We will use ESM to probe student frustration and engagement, and to guide collection of more in depth data. We seek to describe ways in which students negotiate episodes of confusion to develop shared understanding. This talk will provide an overview of the ongoing project, and will discuss how we have adapted the project in response to COVID.

Session: PS.D-SU-06 PER: Diversity, Equity & Inclusion II

Sunday, August 1, 2–3:15 p.m. Sponsor: AAPT Presider: *TBA*

PS.D-SU-6.01: Physics Teachers' Framings of Equity and Anti-racism

Contributed – Tra Huynh, University of Washington Bothell

Lauren Bauman, University of Washington

Amy Robertson, Seattle Pacific University

Rachel Scherr, University of Washington Bothell

With the on-going anti-racism movement in the U.S., teachers have been encouraged to incorporate anti-racist activities and curricula in their classrooms. In the Energy and Equity summer workshop 2020, we listened to high school physics teachers compare the lenses of antiracism and equity. We identified three themes that characterize these high school physics teachers' discourse about the relationship between equity and anti-racism. The findings provide insights into physics teacher conceptions about anti-racist lens and their thoughts and concerns in taking up an anti-racist lens for their practice.

PS.D-SU-6.02: Students' Use of Disability Accommodations in Emergency Remote Teaching

Contributed – Erin Scanlon, University of Connecticut, Avery Point

Michael Vignal, Bethany R. Wilcox, Jacquelyn J. Chini, University of Central Florida

Disability is an important aspect of diversity but there are barriers to access and participation for disabled students inherent in the design of physics courses. To help counteract these barriers, universities are required to provide reasonable accommodations for disabled students. However, not all students use accommodations because of social factors (e.g., disability stigma) and others do not have access to professional diagnosis. With the decision to switch to emergency remote teaching (ERT, some educators believe that courses are inherently more accessible. The purpose of this study was to explore the experiences of students who identify with a disability/impairment who were taking a physics course in Fall 2020 to inform policies about providing access to students in future remote and face-to-face courses. In this talk we will present ethical considerations of conducting research during ERT as well as findings related to students use of accommodations and perceived effectiveness in physics courses.

PS.D-SU-6.03: Reflective Journaling in the Era of COVID

Contributed – Ana Barrera, San Francisco State University

Kim Coble, Bahar Amin, Amal Egad, Niah Freeman, Jomar Lopes, Rachel XieSan Francisco State University

The Alma project was developed at San Francisco State with the purpose of promoting inclusion and affirming students' identities by encouraging self-reflection through journaling. After the Alma Project was successfully piloted in 2018 in Supplemental Instruction (SI) classes, it further expanded into all SI classes as well as introductory physics and astronomy labs. In Spring 2020, reflective journaling was used as an asset-based tool to center student voices in physics classrooms and to recognize students' experiences transitioning to online learning during the COVID-19 global pandemic. In addition, a question was added to lab experience surveys to understand students' experiences with remote learning during COVID-19. Essays (N = 257) and surveys (N = 1031) were analyzed using an iterative thematic coding approach. Based on these surveys and essays, we identify themes of positive and negative impact of online teaching and learning as well as strategies students described for self-care.

PS.D-SU-6.04: Evolution of Grades and Social Comparison Concern within a Course

Contributed – Srividya Suresh, the Ohio State University

Andrew Heckler, the Ohio State University

We investigate the evolution and associations between exam grades and Social Comparison Concern (SCC) among students in an introductory calculus-based physics course. SCC is a scale measuring the concern over one's own ability or performance relative to others and has previously been found to be moderately correlated with grades. We hypothesize a mutual influence between grades and SCC. Using a structural equation model, we find evidence that exam scores partially mediate changes in SCC scores, and in turn, SCC scores partially mediate changes in exam scores, though the mediation effects are somewhat small, around 10% of the total effects between grades and SCC. We also find that while SCC scores are correlated with exam scores, they are only very weakly correlated with non-exam grade components. Overall, the results provide evidence for a dynamic feedback loop in which SCC may either negatively or positively interfere with student performance on exams.

PS.D-SU-6.05: The Universal Design for Learning Instructional Practices Observation Protocol (UDL-IPOP)

Contributed – Jacquelyn Chini, University of Central Florida

Erin Scanlon, University of Connecticut, Avery Point

Westley D. James, Lake Mary High School

Sacha Cartagena, University of Central Florida

Universal Design for Learning (UDL) is a recommended framework to facilitate proactive design of instructional environments that support variation in learners' needs, abilities, and interests. However, little empirical research describes what UDL looks like in postsecondary STEM education, and there is not a unified method for "measuring" the enactment of UDL-aligned practices. After using an existing UDL observation protocol designed for K-12 education, we began developing a tool to meet the unique needs of postsecondary STEM education research and development—the Universal Design for Learning Instructional Practices Observation Protocol (UDL-IPOP) . This talk will describe our development process, including working with researchers and instructors to set goals for the protocol (i.e., useful to both faculty and researchers; measures amount of UDL-aligned strategies implemented; observed strategies aligned to UDL checkpoints) and exploring the pilot protocol with experts (e.g., STEM education researches, instructors and disability experts), and the current status of the protocol.

PS.D-SU-6.06: Cultural Capitals Expressed through Reflective Journaling in Introductory Physics Labs

Contributed – Kim Coble, San Francisco State University

Ana Maria Barrera, Bahar Amin, Mireya Arreguin, Amal Egad, Marissa Harris, Jomar Lopes, Alejandra Lopez-Macha, Rachel Xie, San Francisco State University

Khanh Tran, Purdue University

Through reflective journaling, the Alma project at San Francisco State University (an HSI) seeks to affirm STEM students' identities, support connections with their life experiences, and recognize their cultural wealth. Our department offers a number of introductory physics and astronomy lecture and lab sequences including: a three-semester calculus-based physics sequence targeted toward engineering, computer science and physical science majors; a two-semester algebra-based physics sequence targeted toward students in the biosciences; a one-semester conceptual physics course; and one-semester conceptual astronomy course. In response to the prompt "why am I here," designed to draw out their values and purpose, students journaled for 5 - 10 minutes and then spent time in class sharing their responses. Using an iterative thematic coding approach, we analyzed more than 400 essays and identified 11 cultural capitals expressed by students. Here we compare and contrast the frequencies of cultural capitals exhibited by respondents in different course types.

PS.D-SU-6.07: Experts' Perspectives on Disability in Postsecondary STEM Across Disciplines

Contributed – Camille Coffie, University of Central Florida

Erin M. Scanlon, University of Connecticut, Avery Point

Jacquelyn J. Chini, University of Central Florida

Individual instructors' perspectives of disability impact the experiences of disabled students. For example, if a person considers disability as mainly an individual deficit (i.e., aligned with individual or medical models), they will likely place the onus on the disabled student to fit into the existing education system. On the other hand, if a person considers disability as arising from the interaction of socially constructed spaces and practices (i.e., aligned with a social model), they may more likely consider systemic reform. As part of developing an observation protocol for inclusive teaching practices in postsecondary STEM, we interviewed experts from several relevant disciplines, including postsecondary physics and chemistry instructors, STEM discipline-based education researchers, and researchers in exceptional/special education. We will present convergences and divergences in the trends of how these experts discussed disability and inclusive teaching in postsecondary STEM and consider the implications of these perspectives for disabled students.

Session: PS.D-SU-7 PER: Student and Instructor Support & Professional Development, Program and Institutional Change III

Sunday, August 1, 2–3:15 p.m. Sponsor:AAPT Presider: *TBA*

PS.D-SU-7.02: Active Learning in Intro Courses: Study of 18 High-use Departments

Contributed – Alexandra Lau, Western Michigan University

Charles Henderson, Christian Merino, Western Michigan University

Marilyne Stains, University of Virginia

Melissa H. Dancy, Dancy Consulting

In 2019 we conducted a nationwide survey (n=3,769) of teaching practices in introductory undergraduate math, physics, and chemistry courses. Survey results identified departments in the top quarter of their discipline in terms of class time spent on non-lecture activities in their introductory courses. Interviews with members of these departments allowed us to identify factors contributing to their success. We interviewed 29 instructors from 18 departments (including 11 physics instructors representing 6 departments), sampling from a range of institution types. We found that departments with high use of active learning in intro courses have local champions of teaching reform who are very knowledgeable about pedagogy and are supported concretely by institution and departmental resources and culture. In this talk, we will present our model of the factors influencing teaching in departments with high use of active learning in their intro courses, and discuss the practical implications of these findings.

PS.D-SU-7.03: Modeling Disrupting Disenfranchising Narratives about Students in Faculty Conversations

Contributed – Stephanie Williams, University of Maryland

Chandra Turpen, University of Maryland

Over the last 4 years, our team has been designing and running online faculty learning communities (FOLCs) to support faculty in adapting the Next Generation Physical Sciences and Everyday Thinking (NGPET) curriculum to their contexts. Due to the highly interactive nature of the NGPET curriculum, faculty often discuss issues with student collaboration and pacing. In these conversations, faculty, at times, bring disenfranchising narratives about students to the table when making sense of these problems of practice. We investigate when disenfranchising narratives are disrupted in these conversations in an effort to understand how this disruption occurs. Additionally, we will investigate when these discursive challenges succeed in converging on more liberatory narratives about students. In this talk, we will showcase examples of disenfranchising narratives about students, how these narratives are disrupted discursively, and how the conversations converged.

PS.D-SU-7.04: Department and institution factors supporting active learning in intro courses

Contributed – Christian Merino, Western Michigan University

Alexandra C Lau,Charles Henderson, Western Michigan University

Marilyne Stains, University of Virginia

Mellissa H Dancy, Dancy Consulting

In 2019 we conducted a nationwide survey (n=3,769) of teaching practices in introductory undergraduate math, physics, and chemistry courses. Survey results identified departments in the top quarter of their discipline in terms of class time spent on non-lecture activities in their introductory courses. We interviewed 29 instructors from 18 of these departments (including 11 physics instructors representing 6 departments), sampling from a range of institution types, in order to identify factors contributing to their success. We found that departments with high use of active learning in intro courses have local champions of teaching reform who are very knowledgeable about pedagogy and are supported concretely by institution and departmental resources and culture. In this talk, we focus on the variety of institution and department level characteristics that were present in departments with high use of active learning in their intro courses and how they differentially supported teaching reform.

PS.D-SU-7.05: Teacher Views of Physics-based Engineering Activities

Contributed – Alexandria Muller, University of California, Santa Barbara

Allyson Randall, Danielle Harlow, University of California, Santa Barbara

Ron Skinner, MOXI, The Wolf Museum of Exploration + Innovation

Research has shown that elementary school teachers report an intention to integrate engineering education into their classrooms (Uğrağ& Genç, 2018; Kang, Donovan & McCarthy, 2018); however, they also report low confidence in their ability to teach engineering (Trygstad, 2013). In response, we developed curricular modules that include both physics and engineering instruction through a partnership with a local interactive science center. Each module includes four activities that include an investigation about a physics phenomenon and introduces the engineering design process across the classroom and museum learning spaces. In this paper, we analyze post-module interviews with K-6 grade teachers to understand their view of engineering activities. Using Activity Theory (Engestrom, 2000) to guide our work, we present a snapshot of teacher perceptions and suggestions for supporting teachers when engaging students in physics-based engineering design activities. These findings are also useful for other physics outreach programs that work with elementary teachers.

PS.D-SU-7.06: Fostering Departmental Change through Collaboration: An Analysis of Two Approaches

Contributed – Alanna Pawlak, University of Colorado Boulder

Kristin Oliver, Sarah E. Andrews, Cynthia Hampton, Noah D. Finkelstein, University of Colorado Boulder

Change efforts in higher education are increasingly focused at the department-level, allowing for the benefits of a grassroots approach while also incorporating top-down implementation. Two models for departmentally-based change are the Departmental Action Team (DAT) Project and Teaching Quality Framework (TQF) Initiative. In both models, externally-facilitated working groups meet regularly to work on projects relevant to their departments, though the focus and scope of teams' work differs. To better understand how these models of institutional change operate and their implications for change work in higher education, we interviewed individuals from both efforts, including facilitators and grant PIs. Our results indicate that differences between the models have connections to the theories underlying each, and they have implications for participants' experiences and working groups' outcomes. We present the similarities and differences in the working group process in the two change models, and their implications for others doing departmental change work.

PS.D-SU-7.07: Enabling Content-specific Discussions Among Expert-novice Reacher Pairs: A Case Study

Contributed – Margaret "Maggie" Mahmood, University of Illinois at Urbana-Champaign

Facilitating discussions on pedagogy and content among high school teachers with different backgrounds can be a challenging undertaking. By becoming attuned to the mechanisms by which discourse moves in expert-novice teacher pairs successfully elevate conversations about content and pedagogy, facilitators of physics teacher professional development (PD) can better design activities and support teacher groups in advancing toward a conversational mode in which all parties feel comfortable contributing. Last summer, the Illinois Physics and Secondary Schools (IPaSS) partnership offered intensive PD workshops for high school teachers. This talk presents a case-study of an expert-novice pair solving problems from a Content Knowledge for Teaching Energy (CKT-E) assessment. Via video analysis, we examine the question: What conversational moves facilitate conversations about physics content and pedagogy between teachers with different backgrounds? In the case study, moves by both teachers minimize apparent disparities in power, creating conversational space and setting the stage for content-specific discussion.

Session: PS.D-SU-8 Science Advocacy and Communicating with Elected Officials

Sunday, August 1, 2–3:15 p.m. Sponsors: Committee on Professional Concerns, Committee on Science Education for the Public Presider: *Joseph Kozminski*

PS.D-SU-8.01: STEM Education and Education Research as Tools for Science Advocacy/Communication

Invited – Rebecca Rosenblatt, AAAS-Science and Technology Policy Fellow

I have been serving as an AAAS-Science and Technology Policy Fellow at the National Science Foundation in the Division of Undergraduate Education for the last two years. I will share lessons learned from this experience about communicating with government officials. Specifically, I will focus on reframing STEM education and education research as multifaceted tools for science advocacy. I will also discuss program and project evaluation as underutilized tools for the promotion of STEM. Improving the way educators and educational researchers collect and share project and program results can facilitate communication among researchers, educators, nonprofits, and government and assist these entities in promoting STEM and STEM education.

PS.D-SU-8.02: NASEM's Committee on Planetary Protection: Advocating With and for Science

Invited – Daniel Nagasawa, Space Studies Board, National Academies of Sciences, Engineering, and Medicine

The National Academies of Sciences, Engineering, and Medicine (NASEM) provide independent, science-based, non-partisan policy advice to federal agencies and Congress. The Committee on Planetary Protection (CoPP), a discipline committee of the Space Studies Board, advises NASA on the critical issue of planetary protection. Planetary protection includes measures devised for robotic spacecraft and human exploration missions to protect the biological and environmental integrity of extraterrestrial bodies for future scientific studies as well as life on Earth against potential "backward" contamination. Through its reports and discussions with scientists across the world, the CoPP endeavors to ensure that space missions can answer fundamental questions about life and the history of our Solar System without jeopardizing future science through harmful contamination of pristine extraterrestrial sites. I will discuss how CoPP and similar committees demonstrate science advocacy and communication with government officials, and how CoPP uses science to promote and protect future studies and exploration.

PS.D-SU-8.03: Perspectives from Inside and Outside: Advocating for Science and Policy

Invited – Gerald Blazey, Northern Illinois University

As with any form of communication, advocacy for science and science policy requires identifying key audiences and opportunities. In this presentation, some of the main opportunities for advocacy with the Executive and Legislative Branches are identified and illustrated. As a preface and because of tight coupling with advocacy opportunities, the Federal budget cycle is briefly reviewed. The speaker has participated in science advocacy and policy development from multiple perspectives as a member of the Department of Energy Office of High Energy Physics (2007-2010) and the White House Office of Science and Technology Policy (2011-2014) and with responsibility for university federal relations at Northern Illinois University.

*Sponsor: Dr. Joseph F. Kozminski, Lewis University

PS.D-SU-8.04: Engaging in Policy in the Time of COVID and Beyond

Invited – Erin Heath, American Association for the Advancement of Science

Scientists and educators can engage in public policy in a range of ways, from simple activities that take just an hour of time to year-long policy fellowship opportunities. This talk will offer practical tips for getting started in science advocacy and reflect on how policy engagement and science advocacy might be different following the pandemic.

PS.D-SU-8.05: Physics: The River that Runs Through It All

Invited – Shirley Jackson, Rensselaer Polytechnic Institute

President Shirley Ann Jackson of Rensselaer Polytechnic Institute will discuss her own educational path, which led her to a doctorate from MIT in theoretical elementary particle physics, and the ways that her research career in condensed matter physics expanded into government, corporate, and academic leadership roles at the highest national levels. She will consider “the Quiet Crisis”, America’s national need to bring women and underrepresented minorities into STEM fields in sufficient numbers, while continuing to attract talent from abroad. She will offer observations and ideas for the ways that the nation’s physics teachers can help to bring the full talent pool into the field, as well as comment on the role of physics and physics-based education in creating a foundation for addressing complex global challenges – for individuals and collaborative groups.

Session: PS.D-SU-9 Teaching Online/Remote Physics Classes Sunday, August 1, 2–3:15 p.m.

Sponsors: AAPT **Presider:** *TBA*

PS.D-SU-9.01: Application of Red Pitaya STEMLab to Remote Advanced Laboratory Teaching

Contributed – Andres Reyna, MIT

Gladys Vélez Caicedo, Sean Robinson, MIT

In the era of remote learning, physics labs at all levels are facing the challenge of teaching students experimental and instrumentation techniques without the use of equipment present in the lab. Red Pitaya’s STEMLab offers an effective, low-cost (few hundred dollar), all-in-one solution to this issue. The STEMLab functions as a multifunction lab instrument. It is capable of emulating a wide range of benchtop test equipment, such as oscilloscopes, function generators, multi-channel analyzers, and network analyzers. When its portability and ease of use is also considered, the Red Pitaya platform becomes an extremely effective teaching tool for remote learning at all levels. We report on the use of Red Pitayas in an advanced undergraduate physics laboratory in order to teach students basic instrumentation science, as well as its integration and performance in existing experiments such as muon lifetime analysis and laser-locking systems.

PS.D-SU-9.02: Demonstrating Physics in the Remote Landscape

Contributed – Monika Wood, University of Michigan

During the pandemic, the format of class instruction changed from in-person to entirely remote. What does a group that provides physics demonstrations to lecturers to supplement instruction do to continue to offer the same level of access to our catalog? We digitize! Working with instructors to identify their needs, we provided short videos of demonstrations performed in various ways. By using multiple cameras, professional editing software, strategic planning, and youtube we have compiled a physics demo video library accessible to the world. Here is what we learned on our journey.

PS.D-SU-9.03: Simulation Lab with Mathematica

Contributed – Daniel Gebreselasie, Galveston College

Common experiments in General physics courses will be simulated using the manipulate function of Mathematica. These experiments include vector addition, force table, projectile motion, circular motion, torque, Archimedes' principle, harmonic motion of a spring, harmonic motion of a pendulum, standing waves, Circuits, Faraday's law and lenses.

PS.D-SU-9.04: Development of Online Labs for a Physics of Music Course

Contributed – Sarah Phan-Budd, Winona State University

Online labs can be challenging to run and may require students to buy or borrow expensive equipment to complete. This talk will focus on the development of online physics of music labs that require little equipment beyond what students might already own. These labs use open-source software and other free resources to implement. We will discuss the advantages and disadvantages of such an approach, and why you should consider adding physics of music labs to your current online freshman physics course.

PS.D-SU-9.05: Implementation of Modified Team-based Learning Approach in Online Physics Courses

Contributed – Edgar Corpuz, University of Texas-Rio Grande Valley

A modified team-based learning (TBL) approach was implemented in calculus-based physics courses in online synchronous format during the COVID-19 pandemic. In this modified TBL teaching approach, students were pre-assigned to study course materials (e.g. micro-lectures) then they complete an individual quiz. Afterwards, they take the same quiz with their group during a breakout session in zoom. This presentation will document the effect of the implementation of the modified TBL approach during the COVID-19 pandemic on students’ attitudes, motivation, self-efficacy, self-determination, and course performance.

Session: PS.D-SU-10 The Effective Practices for Physics Programs (EP3) Guide and Departmental Action Leadership Institutes (DALIs)

Sunday, August 1, 2–3:15 p.m. Sponsor: Committee on Physics in Undergraduate Education **Presiders:** *Sarah McKagan, David Craig*

PS.D-SU-10.01: Department Chairs Report Misalignment Between their Current and Ideal Departments

Invited – Robert Dalka, University of Maryland, College Park

Sara Frederick, Chandra Turpen, University of Maryland, College Park

Joel Corbo, University of Colorado, Boulder

Stephanie V Chasteen, Chasteen Educational Consulting

The APS Effective Practices for Physics Programs (EP3) project team surveyed department chairs nationwide to assess the status of physics-degree-granting departments. The results give insight into how chairs viewed the state of their undergraduate programs in 2020. The findings cover a range of areas, including the problems departments face, the departmental cultures of assessment, and attitudes towards program review. Recruitment and retention of minoritized students and overall student enrollment and preparation were the most prevalent and severe departmental problems reported. Note, pandemic related issues were not addressed as at the time of this survey as it was unclear what the total effect of the pandemic would be. Additionally, there is substantial misalignment between chairs’ current and ideal departments, indicating room for improvement in departmental practices and change processes. In this talk, I will share these survey results and discuss the implications for the EP3 project and the larger physics community.

PS.D-SU-10.02: EP3: A Comprehensive, Community-Sourced Guide for Improving Departments*

Invited – Theodore Hodapp, American Physical Society

Michael Jackson, Millersville University

David Craig, Oregon State University

Sarah McKagan, McKagan Enterprises

Collecting effective practices across all areas of a physics department's operations is a daunting task for any chair or faculty member bent on improving their program. EP3 (Effective Practices for Physics Programs) is a community-sourced guide to help chairs and members of their department improve. The guide includes sections on topics including recruitment, retention, introductory-courses, laboratory and computational skills, undergraduate research, culture and climate, equity and inclusion, leadership, program review, capstone experiences and much more. Guide development is ongoing, but a substantial portion is now available at EP3guide.org and the national task force is set to complete all sections by early 2022. This talk will provide an overview of the guide, its design, and how to begin to use the practices. Our interactive session will provide an opportunity for attendees to provide feedback on design and content, and to see how you can use the guide most effectively.

*This material is based upon work supported by the American Physical Society and the National Science Foundation under Grant Nos. 1738311, 1747563, 1821372, 2033894. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

PS.D-SU-10.03: Toolkit for Departments Under Threat

Invited – James Borgardt, Juniata College

Courtney N Lannert, Smith College/UMass-Amherst

APS has recognized that physics programs and departments have increasingly come under threat in the current climate in higher education, a circumstance exacerbated by COVID. This has particularly impacted regional public institutions and private colleges. In response, APS tasked the authors to develop a resource that could aid departments experiencing such pressures. We conducted over 50 interviews with faculty and administrators, gathering practices that worked, or did not work. These practices served as feedstock for the resulting web-based resource: the Toolkit for Departments Under Threat. The Toolkit provides guidance on effective practices, and presents these findings in structures that can easily be adopted by departmental leaders. While each individual program constitutes a unique ecosystem, thematic elements emerged, forming the backbone of the Toolkit. We will describe the structure and content of the Toolkit, and invite any feedback.

PS.D-SU-10.04: Supporting Departmental Change Efforts with Departmental Action Leadership Institutes (DALIs)

Invited – Joel Corbo, University of Colorado Boulder

David Craig, Oregon State University

As part of the EP3 Project, we are piloting Departmental Action Leadership Institutes (DALIs), which support faculty members and their departments in implementing changes to their undergraduate programs. Starting in January, two faculty members from each of five departments joined the first DALI. They were charged with leading cross-constituency teams in their departments to engage in a change effort, following the Departmental Action Team (DAT) model. This DALI started with a virtual kickoff workshop followed by twice monthly meetings and the opportunity for individual consultations with the DALI facilitators. These activities were designed to to help the DALI participants engage in a change effort, supporte a high-functioning team, interface with external stakeholders, and develop change agency. In this presentation, we will describe the goals and structure of the pilot DALI, present some initial feedback from our participants, and describe our plans to document the impacts on participants and their departments.

Session: PS.D-SU-11 Voices from the Field: COVID and Support for Transitions in Course Delivery Modes

Sunday, August 1, 2–3:15 p.m. Sponsor: Committee on Teacher Preparation Presider: *Kathleen Harper*

PS.D-SU-11.01: How it Started, How it's Going, I'm Tired

Invited – Kevin McChesney, Douglas R Forrest, Pickerington Local School District

How it started:
Spring 2020 –Thrown overboard with a lead vest on
Fall 2020 – Trying to swim ashore against the current
How it is going:
Spring 2021 – Row, row, row your boat navigating the rough seas is possible with steering, guidance, and your oars in the water.
Veteran teachers take a journey they'd never planned, hadn't trained for, didn't want, but had to be done. Learning through adversity to become better teachers and adapting and readapting to students' needs on the fly.

PS.D-SU-11.03: This Is My Normal: Navigating COVID-19 as a New Teacher

Invited – Ryan Elder, Thomas Jefferson HS for Science & Technology

August 26th 2019 was my first 'First Day of School'. 199 days later, on March 12th, 2020, I would collect my belongings as usual, lock my classroom door, and offer a cheery "see you tomorrow!" to my colleagues. Unbeknownst to me, 'tomorrow' wouldn't happen, as the COVID-19 pandemic was about to erase the classroom routines I had worked so hard to establish. Public education as I knew it would be disrupted across the globe: classrooms would be exchanged for home offices, worksheets traded for laptops, and all models of traditional assessment and instruction would be re-evaluated. In this talk I will discuss my own experiences as a new teacher navigating through the COVID-19 pandemic and, in particular, reflect on how well my teacher preparation program prepared me for the unexpected.

PS.D-SU-11.04: Ready or Not? Navigating the Classroom During a Pandemic

Invited – Tiffany Taylor, Rogers High School (Rogers, AR)

During the 2020-21 school year, our school adopted a blended learning model in which we taught students face-to-face 5 days a week and also instructed students learning remotely. In the summer leading up to school, I learned several tools and techniques to shake up the "normal" and create digital lessons, assessments, labs, and classroom discourse. The changing face of the school year, where different students learned remotely for varying lengths of time, also introduced new challenges that were anticipated, but never before navigated. In this talk, I share these challenges (including months where students could apply to be remote for 2 weeks at a time), and how "ready" I was for this task through my teacher preparation. I also describe why, despite these challenges, I am excited to keep some of these new approaches — and also why I am more than ready to let some of them go.

Session: PS.D-SU-12 Sharing Best Ideas: Teacher Training and Enhancement + Learning Planetaria

Sunday, August 1, 2–3:15 p.m. Sponsor: AAPT Presider: *Jeannette Lawler*

PS.D-SU-12.01: Using a Planetarium to Demonstrate the Scope of the Universe

Contributed – Maureen Hintz, Utah Valley University

Students with all types of experience register for our Descriptive Astronomy class (Astro 101) and many have no concept of the size and scope of objects of the Universe. I use our planetarium extensively during the semester to show actual astronomical objects, but especially to give students a better understanding of the scope and scaling of those objects. I will share some of the planetarium (Digistar 5) experiences that have been effective at helping students appreciate the scope and scale of the universe over the years.

PS.D-SU-12.02: Planetaria Beyond the Introductory Level

Contributed – David Klassen, Rowan University

Amy Barraclough, Benjamin West, Rowan University

Our introductory astronomy courses have made use of our planetarium for the "standard" lessons, such as teaching students about celestial coordinates, the ecliptic, etc. We have several advanced courses in our minor in astronomy, including a sophomore-level course on the solar system and exoplanets, and introductory astrophysics, and junior courses on observational astronomy, stellar astrophysics, and galactic astronomy. We recently began thinking about using the planetarium to help with instruction at these higher levels. In the fall of 2019, we started teaching lessons for our solar system course in the planetarium, which would have been modified and expanded upon in 2020, but for the COVID-19 shutdown. We will present our initial work from 2019 and plans for improvements and additions for fall 2021, and preliminary ideas for our stellar astrophysics course planned for spring 2022. We hope to spark a further discussion on the use of planetaria for higher-level courses.

PS.D-SU-12.03: Integrating Energy and Equity: A Case Study from Teacher PD*

Contributed – Amy Robertson, Seattle Pacific University

Tra Huynh, Clausell Mathis, Lauren C Bauman, University of Washington

Multi-cultural education and culturally responsive pedagogies invite teachers to support students in critiquing the foundations of the discipline, with the aim of reimagining the discipline and the purposes it serves. The Energy and Equity Project is creating professional development for high school physics teachers that integrates physics content with equity learning, including supporting teachers in understanding ways in which inequities are built into the concept and applications of energy. In the first iteration of our summer workshop, high school physics teachers regularly named both a desire to integrate equity and the concept of energy and confusion about how they might accomplish this. This talk will look at a case of a teacher who made progress in her thinking about the integration of equity with the energy concept of efficiency. We use this case to pose some hypotheses about how to support learning of this kind.

*This work was supported in part by NSF Grant Number 1907815.

PS.D-SU-12.04: #Leadership goals

Contributed – Shannon Wachowski, PEER Physics, Wyoming Department of Education

Nicole Schrode, PEER Physics, Saint Vrain Valley School District

What are your #LeadershipGoals? All educators are leaders: in their classroom, department, institution, and personal life. During this talk, participants will reflect on how they envision themselves as a leader, engage with a self evaluation tool, and consider the steps in developing an action plan for making change in their leadership life. In anticipation of the soon-to-be-published guide Honoring Teachers as Professionals: Stories and Pathways for Growth in Your Classroom and Career through AIP Publishing, the authors will share how university/K-12 partnerships led to increases in their own leadership capacity, professional networks, and improved professional development opportunities through self-reflective classroom research. We will discuss research and experiences around these partnerships, leadership in education, goal setting, and how participants can work towards the same.

PS.D-SU-12.05 : Introduction to Microfabrication Techniques. An intensive Ccourse

Contributed – Juan Merlo, Vassar College

Modern technology is based on well-developed fabrication techniques. Among these techniques, photolithography is one of the most used in industry and research. Unfortunately, the experiences that undergraduate students can have using these fabrication techniques is still limited. In this sense, I have developed an intensive course that allows students to get experience on the equipment, parameters, and skills that are required to successfully create patterned structures based on photolithography by using easily accessible equipment. Over one semester, the students have gotten structures that can reach dimensions in the order of tens of microns and reproducibility in the order of 90%. This intensive opens the opportunity in undergraduate institutions to provide required skills to students that will be part of the upcoming work force.

DEI Resource Room: The Pandemic and Its Impact on Women

Sunday, August 1, 2–3 p.m. Sponsor: DEI Resource Room

Organizers: *Laura McCullough, University of Wisconsin - Stout and Emily Marshman, University of Pittsburgh*

Session: PS.E-MO-1 Forming an AAUP Chapter Monday, August 2, 10–11:15 a.m.

Sponsors: Committee on Physics in Undergraduate Education, Committee on Professional Concerns **Presider:** *Jennifer Blue*

PS.E-MO-1.01: Supporting Faculty During the Pandemic and Beyond

Contributed – Cathy Wagner, Miami University

Our higher education system is in danger. At many of our universities, top-down decision-making, austerity thinking and repeated budget cuts have led to declines in educational quality, research, and faculty well-being. The pandemic has increased workloads and deepened existing inequities, bringing the need for changes in institutional priorities into sharp focus. How can faculty build collective power to counter harmful policies and practices and seek effective shared governance on campus? This talk will explain how AAUP advocacy chapters can promote our educational mission and support faculty by sharing information, using media pressure and existing governance structures as tools for change, and building power through solidarity. The talk will also address differences between advocacy chapters and unions. While advocacy chapters can be powerful forces for positive change, collective bargaining units can negotiate binding agreements that have more power to improve faculty lives.

PS.E-MO-1.02: Forming an AAUP Chapter at Your Institution

Contributed – Michael Magee, American Association of University Professors

AAUP has represented the voice of faculty and defended the flagship standards for shared governance and academic freedom for over 100 years in American higher education. At the campus level, AAUP Chapters form the backbone of the Association, giving faculty a vehicle to advocate for themselves and make lasting changes to the status-quo. This session explores the benefits of AAUP membership and details how an AAUP chapter can transform your campus. It will also introduce the uninitiated to AAUP's history and mission, with a special emphasis on the natural sciences.

PS.E-MO-1.03 How to Talk About Sexual Harassment

Invited – Melinda McCormick, Western Michigan University - Kalamazoo, MI

Ramon Barthelemy, University of Utah

Addressing sexual harassment requires an understanding of what it is as well as the impact it can have upon persons who experience it, the ability to discuss it in our workplaces, and workplace structures and policies for addressing it. Women who enter the field of physics have frequently reported experiencing sexual harassment and have discussed how it impacts them in terms of persistence in the field. In order to create physics environments in which women feel valued and respected, it is necessary to educate both ourselves and those in our workspaces and to have difficult conversations about sexual harassment. Education on sexual microaggressions is a helpful starting place for understanding sexual harassment and opening conversations. This talk will begin this conversation by presenting findings from a study exploring the gender discrimination experienced by women Ph.D. students in physics and astronomy.

Session: PS.E-MO-2 Introductory Courses II

Monday, August 2, 10–11:15 a.m. Sponsor: AAPT Presider: *TBA*

PS.E-MO-2.01: Impact of Remote Instruction Modality on a Two-staged Instructional Approach

Contributed – Bijaya Aryal, University of Minnesota Rochester

Kyle McLelland, University of Minnesota Rochester

We have designed an instructional model involving two sessions. The first session involves conceptual model building and the second session involves consolidation and transfer of learning in novel contexts. We have been implementing this model over the last several semesters. However, in the most recent semesters, we implemented this model in a remote instructional approach making adjustments in the instruction. In this presentation, we report the impacts of the modality change in various aspects of student learning of knowledge and skill. We have explored the factors affecting the students' engagement level in remote instruction and subsequently to the student performance. We will describe impacts on students' problem-solving approach and competency. Additionally, the results from the in-class clicker quiz and conceptual exam questions have also provided some useful information. Using the CLASS survey result, we will present the impacts on student attitude about learning physics.

PS.E-MO-2.02: Meaningful Active Learning Environments and the Need for Scientific Practices*

Contributed – Paul Bergeron, Michigan State University

Both Active Learning and Three-Dimensional Learning (3DL) represent major shifts in how introductory STEM courses are taught. These take two separate approaches, with Active Learning focusing on how students learn and 3DL on what students learn. By pairing Active Learning with 3DL, student-centered learning environments can be more meaningful and promote deeper learning by engaging students with the scientific ideas and skills centrally important to our disciplines. In this talk, I will present 2 years of data from including exam assessment items and in-class video recordings from physics, chemistry, and biology courses. Using of the 3D-LAP and 3D-LOP, we have characterized the learning environment for both the potential to engage students in 3DL and the incorporation of active learning strategies. We will discuss how our findings indicate that placing an explicit focus on engaging students in Scientific Practices is necessary for using 3DL to create more meaningfully active learning environments.

*On behalf of the 3DL for Undergraduate STEM group.

PS.E-MO-2.03: Chlorophyll Fluoresces Red!

Contributed – David Waters, University of Health Science and Pharmacy in St. Louis

As an introduction to atomic physics in an algebra-based introductory physics for the life sciences course, students learn how to calculate the energy levels of organic molecules. They use this knowledge to determine the conjugation lengths of the molecules. The students at our university have taken 4 semesters of chemistry before taking physics, so they have a good understanding of organic chemistry. With this method, students are able to find the wavelengths of photons that are absorbed and emitted by these molecules. Students then create mixtures in lab with these organic molecules to see their absorption peaks at specific wavelengths. Once we move into fluorescence, students are able to use their knowledge of energy levels to discover that chlorophyll fluoresces in the red. Only when they get to lab are they able to see this phenomenon in real life and truly appreciate the ideas behind atomic physics.

PS.E-MO-2.05: Toward Expert Level Approaches

Contributed – Marianna Ruggerio, Auburn High School

One of the distinguishing attributes of first year physics students is the novice-style approach to solving problems, typically based upon common variables or equation hunting. Having students shift to more expert-like strategies, based upon more over-arching ideas or concepts is often a challenge in physics teaching. This talk will discuss several strategies implemented in an urban-emergent high school for both traditional junior level students, as well as AP level students to help shift student approaches from novice to expert.

PS.E-MO-2.06: Undergraduates' Understanding of Vector Decomposition of Forces on Inclined Planes

Contributed – Dan Liu

Hashini Mohottala, University of Hartford

Students often struggle to decompose a vector, especially when calculating the force components of an object on an inclined plane. In this study, we designed a vector online survey in the context of physics and implemented it in a primarily undergraduate university. Our preliminary studies indicate the students' learning difficulties and teaching strategies associated with vector decomposition on inclined planes. The analysis of the students' responses indicates that translating a vector at the position with geometric convenience instead of the center of mass can help them identify angles and calculate vector components more accurately; when students are provided with the definition of the angle in the vector component formula, their performance improves.

PS.E-MO-2.07: The Costs to Persist in Introductory Physics for Pre-Health Majors

Contributed – Ivanna Morejon, Florida International University

Daykis Rodriguez, Florida International University

While much of our research centers on recruiting more physics majors, the introductory physics courses serve a variety of STEM majors. Pre-Health majors account for a large portion of student enrollment in introductory physics. In this study, we investigate how Pre-Health majors are motivated to persist in their introductory physics course and how features of the course may shift their perceptions of physics. Pre-Health students are perceived to be extrinsically motivated to persist in their physics class as a means to an end in preparation for their MCAT or curricular requirements. Using Eccles Expectancy Value and Cost Theory, we test and analyze how Pre-Health majors enrolled in Modeling Instruction (MI) course change their perceptions of physics and their physics identity. This study will present results from surveys of about 140 students enrolled in MI in addition to several interviews exploring students' classroom experiences and their reasons to persist.

Session: PS.E-MO-3 LGBT Physicists: Research and Perspectives

Monday, August 2, 10–11:15 a.m. Sponsor: Committee on Research in Physics Education Presider: *Ramón Barthelemy*

PS.E-MO-3.01: A Model of Queer STEM Identity

Invited – Allison Mattheis, Cal State LA

Science, technology, engineering, and mathematics (STEM) fields are often stereotyped as spaces in which personal identity is subsumed in the pursuit of a single-minded focus on objective scientific truths, and correspondingly rigid expectations of gender and sexuality are widespread. This talk describes findings from a grounded theory inquiry of how queer individuals working in STEM fields develop and navigate personal and professional identities. Through our analysis, we identified three distinct but related processes of Defining a queer gender and/or sexual identity, Forming an identity as a STEM professional, and Navigating identities at work. We found that heteronormative assumptions frequently silence conversations about gender and sexuality in STEM workplaces and result in complicated negotiations of self for queer professionals. This analysis of the personal accounts of queer students, faculty, and staff in STEM reveals unique processes of identity negotiation and elucidates how different social positioning creates challenges and opportunities for inclusivity.

PS.E-MO-3.02: LGBT+ Physicists: Harassment, Persistence, and Uneven Support Systems

Invited – Timothy Atherton, Tufts University

This talk will provide both zoomed-out and zoomed-in perspectives of LGBT+ experiences in Physics. Drawing on the results of a study by the American Physical Society, the climate experiences and persistence of LGBT+ physicists will be discussed focusing on intra-group differences: Experiences of exclusionary behavior were found to vary significantly by gender with transgender participants experiencing the most hostile climate; respondents who were out were found to be more comfortable at their workplaces; evidence was also found for differences in experience grounded in intersections with race. The talk will then examine the specific experiences of two LGBT+ individuals as they navigated a course, highlighting key moments where LGBT+ identities foregrounded themselves in the context of disciplinary thinking as well as ways in which existing support structures did not address their needs. These two perspectives will be used to highlight prospects for new research directions around LGBT+ identity in Physics Education.

PS.E-MO-3.03: From LBGT to Queer: Physicists Without Identities

Invited – Darius Bost, University of Utah

This presentation will introduce participants to some of the foundational concerns of queer theory. Beginning in the late 1980s and early 90s, the field of queer studies emerged as a departure from the LGBT scholarship and politics of the 1970s and 1980s. Rejecting assimilationist approaches that demanded sexual minorities be included in mainstream culture and politics, queer scholars sought to maintain the socially transgressive aspects of the culture in an effort to transform dominant ideologies and institutions that made heterosexuality seem normal and natural. Using as examples mainstream political debates that have affected non-heterosexual populations, this presentation rethinks queer, not as an umbrella term for LGBT identities, but as a theoretical field that seeks to unsettle categories of identity, namely gender and sexuality, as sites of normalization and regulation. In so doing, participants will reflect on how queer theory might transform their relationship to the field of physics education.

PS.E-MO-4.01: The Leaky Pipeline in Physics Publishing

Contributed – Clara Ross, Vassar College

Aditya Gupta,Ninareh Mehrabi, Goran Muric, Kristina Lerman, USC

Women make up a shrinking portion of physics faculty in senior positions, a phenomenon known as a "leaky pipeline." While fixing this problem has been a priority in academic institutions, efforts have been stymied by the diverse sources of leaks. In this paper we identify a bias potentially contributing to the leaky pipeline. We analyze bibliographic data provided by the American Physical Society (APS), a leading publisher of physics research. By inferring the gender of authors from names, we are able to measure the fraction of women authors over past decades. We show that the more selective, higher impact APS journals have lower fractions of women authors compared to other APS journals. Correcting this bias may help more women publish in prestigious APS journals, and in turn help improve their academic promotion cases.

PS.E-MO-4.02: Supporting Gender-Equity in the STEM Classroom

Contributed – Lynn Jorgensen, Gilbert High School

While the fields of science, technology, engineering, and mathematics (STEM) have grown in the past twenty years, the proportion of women in these fields has not seen the same growth. This article researches how inquiry-based instructional approaches can better support gender-equity in classrooms. It will look at the effects that confidence, group work, a nd Socratic questioning have on women in STEM courses, and how small changes in instruction can have large impacts on the experiences women have in STEM courses.

PS.E-MO-4.03: Reflection on Underrepresented Curriculum Implementation in an Urban K-12 Setting

Contributed – Lindsay Owens, Purcell Marian High School

Traditional high school physics curricula focused on meeting the Next Generation Science Standards and specific state standards do not typically address issues of racism and sexism in physics. In the 2020-2021 academic year, I facilitated discussions centered on five units from the Underrepresented Curriculum in three high school physical science classes. The curriculum was modified to focus on issues relevant to and valued by my students, (80% black or African American, 10% Hispanic/LatinX, and 10% white or Caucation), such as taking into account their racial and ethnic background, gender, interests, and reading levels. I will offer insight into how the Underrepresented Curriculum can be modified to better relate to students, authenticate physics, and center students' learning on social justice.

PS.E-MO-4.04: Negative Impacts on Female Physics Majors of Cold Physics Environment

Contributed – Lisabeth Santana, University of Pittsburgh

Chandralekha Singh, University of Pittsburgh

This research focuses on experiences of three undergraduate women who are physics majors. Specifically, we conducted semi-structured, empathetic interviews which reveal uncomfortable environments inside and outside of the classroom and how it affected their ability to identify as a physicist. We use standpoint theory to identify key issues that these women physicists face in undergraduate physics programs.

PS.E-MO-4.05: Investigating the Relationship Between Motivation and Retention in Women Undergraduates*

Contributed – Maxwell Franklin, Drexel University

Annette Ponnock, Yale University

Eric Brewe, Drexel University

Renee Michelle Goertzen, American Physical Society

Using the American Physical Society Conferences for Undergraduate Women in Physics (CUWiP) evaluation data, we have asked participants about their path into physics. We present a hand coding of the written responses focusing on their stated motivation, which we will combine with a follow-up survey to study the retention of women undergraduates in physics. The initial coding of the surveys establishes and classifies different types of motivation. These types will then be studied to find whether a correlation exists between motivation and retention. This project will build toward the development of a Natural Language Processing analysis of the same data set with the ultimate goal of developing a predictive tool for retention.

*This work is supported in part by the NSF Graduate Research Fellowship Program, PHY 2011766, PHY 1346627, and PHY 1622510. This project would not be possible without Theodore Hodapp and Zahra Hazari.

PS.E-MO-4.06: Impact of Informal Physics Programs on Female Students

Contributed – Tatiana Erukhimova, Texas A&M University

Jessica Randolph, Emily Hay, Jonan Phillip Donaldson, Texas A&M University

Jonathan Perry, University of Texas at Austin

Informal physics programs can play a vital role in supporting student learning and sense of community beyond the formal settings of a classroom or laboratory. This work builds on a recent study of the role of facilitating informal physics programs on students' physics identity, sense of belonging, and career skills development by narrowing the focus to specifically examine effects on female students who are underrepresented in physics. We found a significant shift in confidence of choice of major when compared prior to and after facilitating informal physics programs. Additionally, all female students who were interviewed discussed the positive intersection between participating in informal programs and their interest and motivation with regards to the field of physics.

Session: PS.E-MO-5 Preparing New Physics Teachers: New Strategies for a New Era Monday, August 2, 10–11:15 a.m.
Sponsor: Committee on Teacher Preparation **Presider:** *David May*

PS.E-MO-5.01: Shoebox PCK: Remote Physics Teacher Education with/on a Shoestring

Contributed – James de Winter, Faculty of Education, University of Cambridge

This session will explore the contents of, the thinking behind and the success or otherwise of box(es) of equipment and resources sent to pre-service physics teachers. These were designed to facilitate remote teaching and self-study sessions that formed part of the teacher education course here in Cambridge, England. Limited by cost and postal box size restrictions, I will share the things we played with, the experiments we carried out and the other activities we did together and apart. I will draw out the wider lessons that I hope were learned from these activities on how to be an outstanding physics teacher. It was fun and I think they learned something. I certainly did and plan to integrate some of this into the course in future years, regardless of circumstantial restrictions.

PS.E-MO-5.02: Recruiting Undergraduate Pre-Service Teachers with a Physics Teaching Methods Course

Contributed – Allison Daubert, Bridgewater State University

Jeffrey Williams, Bridgewater State University

Bridgewater State University is continuing to grow an undergraduate physics teacher preparation program during the pandemic using various strategies. In the Spring of 2020, we began teaching a one credit seminar course called Physics Teaching Methods which runs on a four-semester rotation of topics. The course is designed to attract students early in their undergraduate career, retain their interest in teaching, build physics teacher identity and community, and teach the foundations of physics pedagogical content knowledge. Our course has seen steady enrollment throughout the pandemic even as we switched to an online, synchronous format as well as increasing numbers of enrolled students working as peer tutors and learning assistants in our introductory physics courses. I'll share our experience developing and teaching this course as well as our successes and challenges.

PS.E-MO-5.03: Changes in Preservice Elementary Teachers' Attitudes Toward Computational Thinking

Contributed – Spencer Perry, Indiana University

A variety of pressures are felt by teachers to integrate programming and computational thinking into science classrooms. These pressures primarily arise from the adoption of the Next Generation Science Standards and recent increases in emphasis on computer programming and computational thinking as methods of conducting investigations. Yet many preservice teachers are ill equipped to engage in investigatory computational practices and they often lack strong orientations or beliefs that doing so is valuable. This presentation will outline the preliminary results of an interpretation-based workshop where preservice elementary teachers interpret block coding rather than writing it in order to collect data about a simple ball-on-ramp experiment.

PS.E-MO-5.05: Video Killed the Radio Star: Flipgrid for Online Physics Pedagogy

Contributed – Richard Hechter, University of Manitoba

What started as an impersonal podcast to generate discussions for student journal responses, quickly became replaced with a series of short videos created on DaVinci Resolve and posted on Youtube. Students accessed the videos, and posted their responses, through our class page on the Flipgrid App. The purpose of these videos were three-fold: 1) as inspiration for discussions to elicit critical thinking, reflection, and higher level thinking in small and large-scale aspects of teaching physics, 2) as visual context to pique interest in the content to be covered in the upcoming week, and 3) as an inviting way to engage in flexible and asynchronous conversations, where students were both heard and seen. Videos ended with a prompt that each student responded to using Flipgrid. Join me as I share examples, questions posed, and conversation highlights from this strategy to engage preservice teachers in our physics pedagogy course.

PS.E-MO-5.05: An Alternative to Alternative Physics Teacher Certification in Texas

Contributed – Robynne Lock, Texas A&M University-Commerce

William G Newton, Bahar Modir, Texas A&M University-Commerce

The majority of new high school physics teachers in Texas are certified through alternative certification programs that are not affiliated with institutions of higher education. Teachers certified in this method may not have received adequate preparation for the classroom and are less likely to remain in teaching careers. To make high quality physics teacher preparation more widely available, Texas A&M University-Commerce has created a new fully online M.S. in Physics with Teacher Certification program. At A&M-Commerce, master's degrees incorporating teacher certification include the Post-Baccalaureate Teacher Certification six-course sequence and student teaching. The other half of the classes in this course-based master's degree program are physics content courses developed specifically for educators that include traditional physics content alongside pedagogy, education research, history, and modern applications. All courses are taught online asynchronously, and the student teaching experience can be arranged in different regions across the state.

PS.E-MO-5.06: PhysTEC at Worcester Polytechnic Institute

Contributed – Douglas Petkie, Worcester Polytechnic Institute

Shari Weaver, Rudra Kafle, Thomas P Noviello, Izabela R Stroe, Worcester Polytechnic Institute

The Physics Teacher Preparation Program at Worcester Polytechnic Institute (WPI) is a collaboration between the STEM Education Center and the Physics Department that leverages significant PhysTEC resources that have emerged over the past two decades since PhysTEC started. As a PhysTEC supported site, WPI has been able to implement several key components identified as effective practices at other PhysTEC sites, such as a Teacher-in-Residence to serve as a role model and mentor to students in the program. The PTEPA rubric has allowed our team to strategically plan the next steps in building a thriving physics teacher preparation program. Other elements we will discuss include the Peer Learning Assistant program that includes pedagogical training, a regional physics teacher network, and utilization of the Get the Facts Out resources. In addition to generating interest in high school physics teaching careers, an interest in Physics Education Research has also emerged.

PS.E-MO-5.07: Developing Post-Emergency Field Work Practices from Lessons Learned During 2020

Contributed – Margery Gardner

The most dramatic teacher preparation program shifts during the SARS-CoV-2 global pandemic for our rural liberal arts institution, Colgate University, landed in the arena of field work. Five pandemic era interventions are expected to take hold as embedded future practices. The pandemic afforded greater opportunity to connect with urban educators via teleconferencing technology of both remote and hybrid classrooms. New technologies also engaged pre-service teachers in novel ways through the use of simulation software and video banks of quality teaching from both internal and national sources. Identification of campus wide allies with parallel outreach priorities allowed for the sharing of resources, community contacts, and ideas for transfer to the digital sphere. Close attention to community was accomplished through the use of watch parties and periodic Zoom meet ups with students and alumni from outside geographies. Measures of intervention success will take the form of interviews, surveys, and performance assessments.

PS.E-MO-6.02: Effect of External Resistances on Newton's Second Law of Motion

Contributed – Amritpal Nafria, Lovely Professional University

In this paper, we have practically studied the effect of external resistacnes (frictional forces, air resistances, viscous forces, etc.) on Newton's second law of motion. A mathematical expression (F = ma+r) has been provided by including a factor describing above said external resistacnes. It has been found that in every action some part of the applied force is required to overcome the effect of external resistances. Practically, it has been observed that whenever the applied force exceeds the external resistances then only bodies can accelerate. As per our knowledge, the existing Newton's equation of motion (F = ma) calculates only the motion of accelerated bodies and does not count the applied force till the considered bodies remains at rest. Hence, in this paper, we have included the effect of external resistances to calculate the applied force.

PS.E-MO-6.03: Connecting Simulations to the World

Contributed – Stewart Crawford, Hawaii Pacific University*

During a recent discussion in PICUP (Partnership for Integration of Computation into Undergraduate Physics), it was noted that once a simulation is in hand, students don't necessarily see the connection between the simulation and the "real world". This presentation will demonstrate several examples of making that connection of simulation to world. As a first step, a simulation can be calibrated for digital world consistency, e.g., is a pixels-per-second animation visually accurate? As a next step, when a known physical system is modeled, is the model true to the system? And a further, most powerful step is to run simulations side-by-side with the corresponding physical system. Representative examples will be presented of simulations coded up in Python by high-school physics students, and issues discussed.

*Sponsor: Michael Weber <weberm@byuh.edu>

PS.E-MO-6.04: Student Ownership of Lab Projects: The Role of Interpersonal Interactions

Contributed – Ira Ché Lassen, Western Washington University

Acacia Arielle Evans, Dimitri Dounas-Frazer, Western Washington University

Laura Ríos, Cal Poly San Luis Obispo

Heather J. Lewandowski, University of Colorado Boulder

Ownership is a significant learning goal in many project-based lab courses. An empirical model of ownership will support educators in the practice, design, and implementation of courses that encourage student ownership. In this talk, I will present results of a collaborative, fine-grained analysis on 15 student interviews from 5 Western and Mid-Western institutions. In prior work, our research team described ownership as a relationship among students and their projects that spans three project phases: choosing a topic, executing research methods, and creating deliverables. In each phase, combinations of material, cognitive, social, and affective student interactions compose student-project ownership. This talk will focus on emergent social interaction sub-themes, such as: student 'interpersonal conflicts' and 'project management'; and instructor 'project scoping' and 'troubleshooting'. Elaboration on these themes could point toward pedagogical guidelines that support student feelings of ownership, while also avoiding negative outcomes created by unbalanced project-roles and other conflicts.

PS.E-MO-6.05: Physics and Society: A Course on Power, Justice, and Policy

Contributed – Evan Halstead, Skidmore College

In this talk I will describe a course I developed and taught for the spring 2021 semester as part of a new general education requirement on power and justice. We start by looking at the history of exclusion in physics as well as the currently existing structures and practices that push out members of minoritized groups at various stages of the academic pipeline. The latter part of the course focuses on the roles and responsibilities of physicists in public policy, culminating in an outward-facing project in which students develop policy alternatives for controversial contemporary issues. I will discuss my journey to becoming more comfortable having difficult conversations about diversity, equity, and inclusion, as well as lessons I learned along the way.

PS.E-MO-6.07: Modification of Newton's Second Law of Motion

Contributed – Amritpal Nafria, Lovely Professional University

In this paper, we have practically studied the effect of various resistances (frictional forces, air resistances, viscous forces, etc.) on applied force. It has been found that in every action some part of the applied force is required to overcome the effect of resistances; and when applied force exceeds that amount of applied force only then a body can accelerates. As per study, the existing Newton's equation (F = ma) calculates only the applied force of accelerated bodies and does not count the effect of various resistances till bodies stays stationary or accelerates. Hence, a mathematical expression (F = ma+r) has been provided by including a factor describing above said resistances.

PS.E-MO-6.08: Characterization of Optical Signal by Extension Ratio & the Fiber-Length

Contributed – Ved Nath Jha, Mangalayatan University

In order to improve the performance of fiber network, not only higher quality factor and minimum bit error rate required but also the role of ER cannot be neglected. Since, only the treatment of linear and nonlinear impairments are not sufficient, there must be a need of degradation of signal leakage through the optical fiber networks related to the extinction ratio. Also, the extinction ratio is the significant parameter to measure the optical signal quality of the transmitter and receiver. Therefore, this research is to investigate that how much the effect of ER on the performance of fiber optic networks based on OptiSystem 0.17designed with EDFA and DWDM technology.

Session: PS.E-MO-7 Teaching the Introductory Physics for the Life Sciences (IPLS) Course

Monday, August 2, 10–11:15 a.m. Sponsor: Committee on Physics in Undergraduate Education Presider: *Juan Burciaga*

PS.E-MO-7.01: Centering Units on Biologically and Chemically Authentic Contexts in IPLS-II

Invited – Brokk Toggerson, University of Massachusetts-Amherst

One of the driving goals of IPLS courses is the idea of authenticity. When student see the concepts, language, and epistemological framework of disciplines with which they are familiar, namely biology and chemistry, used in physics, the physics resonates more deeply. This talk shows how a second-semester IPLS course can be built around the idea of authentic questions: both for the course as a whole and for individual units. The particular course discussed is a large enrollment course of one or two sections of three-hundred students each.

PS.E-MO-7.02: IPLS Research and Teaching at a Non-Research State University

Invited – Andrew Mason, University of Central Arkansas

IPLS development, while richly recorded in recent PER literature and online resources, is primarily represented within the context of either large research universities or high-profile liberal arts colleges. This talk concerns preliminary research on an IPLS-appropriate course population in an introductory algebra-based physics course at a primarily-undergraduate regional comprehensive state university in the Southern US. The author's experience pursuing IPLS research in this environment will guide the talk as follows: first, how investigations into IPLS at a non-research university have begun from a PER perspective; second, a brief overview of findings for this population the limitations that affect the implementation of the research; and third, discussion of plans and issues with moving forward from the findings, within a non-research university context.

PS.E-MO-7.03: Two-Semester Intermediate Course Sequence in Physics for the Life Sciences

Invited – Bradley Roth, Oakland University

For 20 years I have taught a two-semester undergraduate sequence in physics for the life sciences: Biological Physics in the fall and Medical Physics in the spring. A typical student takes the courses after completing a traditional introductory physics sequence (the two classes are independent, and can be taken individually or together in any order). The courses emphasize mathematically analyzing models applicable to the life sciences, and assume the student has at least a semester of calculus. Biological Physics covers biomechanics, fluid dynamics, exponential growth, heat, diffusion, osmotic pressure, bioelectricity, biomagnetism, and feedback. Medical Physics covers imaging, tomography, ultrasound, optics, x-rays, nuclear medicine, and magnetic resonance imaging. Most students major in physics, medical physics, or biomedical engineering, although occasionally an ambitious premed, biology, or chemistry student enrolls. A primary goal of the courses is for students to learn how to use mathematical models to gain insight into biological processes.

Session: PS.E-MO-8 Upper Division/Graduate Courses

Monday, August 2, 10–11:15 a.m. Sponsor: AAPT Presider: *TBA*

PS.E-MO-8.01: Student Difficulties with a System of Identical Particles

Contributed – Emily Marshman, Community College of Allegheny County

Christof Keebaugh, Franklin and Marshall College

Chandralekha Singh, University of Pittsburgh

We discuss an investigation of upper-level undergraduate and graduate students' difficulties with fundamental concepts involving a system of non-interacting identical particles. The investigation was carried out in advanced quantum mechanics courses by administering written questions and conducting individual interviews with students. We find that students share many common difficulties related to these quantum mechanical concepts.

PS.E-MO-8.02: Comparing Undergraduate and Graduate Student Reasoning on Conceptual Entropy Questionnaire

Contributed – Nathan Crossette, University of Colorado Boulder

Michael Vignal, Bethany R Wilcox, University of Colorado Boulder

In a prior study, we investigated graduate student reasoning around a set of entropy-related conceptual tasks in a think-aloud format. The tasks involved entropy from microscopic and macroscopic perspectives, ideal gases, and a novel context involving a system with a dynamic string. We conducted interviews with undergraduates using the same questionnaire. Most students were interviewed during the second half of their upper-division Thermal Physics course at the University of Colorado Boulder, while two were upper-division undergraduates from other institutions with strong physics programs. We will explore the similarities and differences between the undergraduate and graduate students' responses in the interviews. In particular, we will compare the conceptual resources used by the two groups of students. The similarity of two of our interview tasks with questions used by other researchers in previous studies of student reasoning with entropy will also allow us to make direct connections with prior research.

PS.E-MO-8.03: Preliminary Findings from a Survey of Quantum Information Science Instructors

Contributed – Josephine Meyer, University of Colorado Boulder

Bianca Cervantes, Gina Passante, California State University Fullerton

Steven Pollock, Bethany Wilcox, University of Colorado Boulder

Quantum information science (QIS) courses have, until now, rarely been a subject of study in the PER community, due in part to their interdisciplinary nature and relatively recent emergence as a widespread curricular topic. We surveyed 116 faculty identified as developing or having taught undergraduate or graduate QIS courses in the US. We have received 26 complete responses, a response rate of 22%. Faculty were asked to describe the structure of the course, as well as any observed student difficulties or identified instructional needs. We also collected basic demographic data such as class size and departmental affiliation. We report on the findings of this survey, with an emphasis on identifying core content areas as well as specific student and instructor difficulties. We expect these findings to be useful in guiding future efforts to develop curricular and/or assessment tools for QIS courses.

PS.E-MO-8.04: Virtual Tour of the Lux-Zeppelin Dark Matter Experiment

Contributed – Margaret Norris, Sanford Underground Research Facility / BHSU

The Sanford Underground Research Facility in Lead, SD is the nation's premier underground laboratory for astrophysics. When COVID-19 caused a sudden halt to the work of the SURF Education and Outreach team in hosting field trips and visiting classes across South Dakota, we pivoted to virtualization of activities and field trips. This includes a 360 degree virtual tour of the Davis Campus, home of the Lux-Zeppelin dark matter detector, which is under commissioning at the current time. The tour is used for middle and high school students, and can be coupled with virtualized presentations and activities pre- or post- tour. Other activities require sending out materials for hands-on activities, including an engineering challenge to design shielding for the detector, and an activity to explore the role of gravity in convincing scientists that dark matter exists.

PS.E-MO-8.05: Automation of QA in Diagnostic Modalities at CFH*– Initial Experience

Contributed – Shriya Ravikanti

Pooja Kasam, Mallikarjuna Rao Kasam

Background: Clinical diagnostic equipment like MRI (Magnetic Resonance Imaging), CT (Computer Tomography), US (Ultrasound), Mammography, Fluoroscopy and DR (Digital Radiography) play a significant role in the diagnosis of diseases and management of patient treatments. Monitoring the Quality assurance (QA) of this equipment is mandatory to obtain optimal images in any of the health systems including the Carle Foundation Hospital (CFH).
Purpose: The goal of the present work is to identify, compare, and measure improvements after digitization and semi-atomization of QA (Quality Assurance) analysis in the diagnostic modality. Methods: The Quality Metrics survey was conducted for accessing these metrics such as Report Turnaround Time, accessibility, etc. for all diagnostic equipment. Results: We discussed the initial outcome of digitization of QA data and their results.
Conclusion: Here. how the introduction to the digitization of QA data by following the American College of Radiology test QA protocols did improve the performance at CFH. *Carle Foundation Hospital

Session: PS.E-MO-9 Voices from the Field: COVID and Support for Transitions in Course Delivery Modes II

Monday, August 2, 10–11:15 a.m. Sponsor: Committee on Teacher Preparation Presider: *Kathleen Harper*

S.E-MO-9.01: Laboratory Strategies in a Hybrid World

Contributed – Adam Lark, Hamilton College

The restrictions placed on physics laboratories by covid-19 forced many instructors to abruptly shift from in-person laboratories to remote or hybrid laboratories. These design limitations required that lab students experience the experimental aspects of lab while potentially not being in-person. This session is an overview of numerous design restrictions that were placed on various physics laboratories and the different solutions used by instructors amid the pandemic.

PS.E-MO-9.02: Challenges with Online Course Delivery for STEM Undergraduates with Disabilities

Contributed – Logan Gin, Arizona State University

Frank A Guerrero, Sara E Brownell, Katelyn M Cooper, Arizona State University

In this study, we explored how the rapid transition to online instruction during the COVID-19 pandemic affected students with disabilities. We interviewed 66 STEM undergraduates with disabilities at seven institutions during spring 2020. We probed to what extent students were able to access their existing accommodations, to what extent the online environment required novel accommodations, and what factors prevented students from being properly accommodated in STEM courses. Using inductive coding, we identified that students were unable to access previously established accommodations, such as reduced distraction testing. We also found novel challenges online that may have been lessened with the implementation of accommodations. Finally, we found that instructors making decisions about what accommodations were appropriate for students prevented some from receiving the accommodations they required in STEM courses. This study illuminates current gaps in the support of students with disabilities and pinpoints ways to make online STEM learning environments more inclusive.

PS.E-MO-9.03: Implementing Authentic Online Assessments in Large Enrollment Introductory Courses

Contributed – Yun Zhang, University Of Missouri - Columbia

In introductory physics courses summative assessment is usually carried out with rigorous on-paper exams that are proctored and manually graded. When instruction was switched to the remote mode in 2020, in my large-enrollment College Physics Courses, implementing authentic online assessments posed significant challenges - for example, how to maintain the rigorousness? How to assess the problem-solving process rather than the final answers to ensure reasonably fair grading? How to make online exams equitably accessible to all students? How to minimize academic integrity violation? In this presentation, I will share the techniques I use to create customized online assessments and the tips for administering online exams.

PS.E-MO-9.04: Impact of Virtual REU Experiences on Sense-of-Belonging and Identity

Contributed – Dina Zohrabi Alaee, Rochester Institute of Technology

Benjamin M. Zwickl, Rochester Institute of Technology

In the Summer of 2020, due to the COVID-19 pandemic, institutions either canceled or remotely hosted their NSF REU programs. We carried out a 16-week longitudinal study examining the impact of these fully remote research experiences on mentees' psychosocial gains (e.g. sense of belonging, identity). We studied the phenomenon of a remote research experience from the standpoint of the mentees (N=10) and their mentors (N=8), who were each interviewed seven and three times, respectively (94 total interviews). All mentees reported that this experience was highly beneficial and that they developed a sense of belonging and identity, despite working remotely — often from their own bedrooms. Mentees developed a sense of belonging through making scientific contributions and through their communication and social interactions with other group members. Additionally, our results demonstrate that mentees' research identity particularly developed through taking responsibility for their work and seeing it valued by others.

PS.E-MO-9.05: Redesigning a First-year Mechanics Course for Remote Teaching During Covid-19

Contributed – Muhammad Syed, Mount Royal University

In May 2020, our University decided to proceed with remote teaching in fall 2020, due to the Covid-19 pandemic. As a result, I spent the spring and summer of 2020 redesigning my first-year physics course on mechanics for remote teaching. Since I have mainly done face-to-face teaching in the past, it was a monumental task to rise up to the challenge posed by this sudden disruption caused by the pandemic to in-person teaching and learning. I attended many workshops and programs to get ideas to meet this challenge. In the redesign, I focused on multiple factors with the overarching aim of maximizing student learning and its social aspects. In this presentation, I am excited to share how all these efforts came together in the form of a new functional course design, and what role my pre-academic experience played in coming up with this new course design.

PS.E-MO-9.06: Community College Student Research Projects in the Time of COVID

Contributed – Jennifer Jones, Arapahoe Community College

Barbra K Sobhani, Red Rocks Community College

Undergraduate research is a critical component of student engagement and retention and the pandemic has challenged us to be creative and adapt. Our colleges have been engaging in collaborative projects for years, establishing a working relationship across campuses, so we were able to leverage this experience to continue working with students on a sounding rocket payload and other projects. The first few months, all work stopped, but we were able to utilize that time to plan. Allowing students to work at home kept the projects alive, weekly journaling kept them communicating and zoom check-ins kept them engaged and accountable. Support from Colorado Space Grant was pivotal in switching to a virtual model, without their support we would not have been able to do robotics and aerospace projects. Burnout is an issue for both students and faculty, as we have supported the stressful struggles of students while going through similar issues.

PS.E-MO-9.08: Remote Active Learning for Large-Enrollment Introductory Physics

Contributed – Aidan MacDonagh, Massachusetts Institute of Technology

Peter Dourmashkin, Michelle R. Tomasik, Alexander J. Shvonski, Joshua J. Wolfe, Massachusetts Institute of Technology

We reflect on the transition of our large-enrollment active learning introductory physics courses from fully in-person to fully remote during the Spring ’20, Fall ’20, and Spring ’21 semesters. First, we discuss the resources and tools we leveraged, including existing interactive content from parallel MOOC courses, randomized online formula response assessments and hand-grading software, and video/audio/board collaboration tools. Next, we describe how the fully remote mode informed our course design changes, such as increasing active engagement during class, lowering the stakes of graded components, promoting group work and community, and creating take-home experiment kits. In addition, we consider modifications made to the workflows and collaboration strategies employed by our team of instructors, TAs, and course developers. Finally, we evaluate the impact of these changes to our performance as a team, the student experience in the course, and the instruction and learning achieved.

PS.E-MO-9.09: Lessons from Student-led Virtual Physics Outreach Efforts during the Pandemic

Contributed – Roberto Ramos, University of the Sciences

As universities adjust to the COVID pandemic, many educational outreach efforts transitioned to the virtual world. In this presentation, I will discuss the challenges faced by university-based, student-led virtual physics outreach to middle school and high school students who were in remote and in-school environments. By collaborating with large STEM collectives, after-school programs, and partner schools, physics outreach efforts from our chapter of the Society of Physics Students led to audiences up to over 130. Successful strategies implemented included the use of accessible physics demonstrations using household materials, hands-on participation by target audiences, virtual tours of laboratories, an interactive Q & A forum, virtual games, and the participation of STEM Career speakers from diverse backgrounds.

PS.E-MO-9.10: Teaching During COVID: What to Keep Beyond the Pandemic

Contributed – Tetyana Antimirova, Ryerson University

From the onset of the pandemic, faculty members across North American universities were provided suggestions for new strategies and best practices to adopt in order to improve remote course delivery. Now, a year later, we have a good understanding of which strategies worked and which ones were not successful in the delivery of undergraduate physics courses. From remote class delivery, including lectures, tutorials and virtual laboratories, to new frameworks for testing and evaluation, the author will share their own personal experience together with what strategies will be retained going forward in a post-pandemic world.

PS.E-MO-9.10: Less is More: At-Home Interferometry in Undergraduate Laboratory Course

Contributed – Benjamin Levy, The University of North Carolina at Chapel Hill

Meghana Sankaran, Shane Brogan, Robert V.F. Janssens, Duane L Deardorff , The University of North Carolina at Chapel Hill

“Experimental Techniques” is an intermediate laboratory course designed in part to help students decide whether they want to pursue experimental physics. Key to this goal are meaningful opportunities for creative exploration and problem solving which mimic real-world research. Despite the COVID-19 pandemic, by building an interferometer at home using inexpensive department-provided materials, students were afforded opportunities for real creativity while proving that changes in optical path length – not just arm length – lead to fringe evolution. Though the physics involved was significantly simpler than in other experiments, students constructed a better understanding of optical path length and interferometry while being introduced to instrumentation and some of the fundamental skills used by experimentalists in the lab. Members of the class also gained a meaningful sense of accomplishment and excitement. Consequently, we are now considering implementing this experiment as part of the in-person version of the course.

Session: PS.E-MO-10 History of Underrepresented Groups in Physics

Monday, August 2, 10–11:15 a.m. Sponsor: Committee on History & Philosophy of Physics Presider: *Kathryn McGill*

PS.E-MO-10.01: Engaging Physics Majors in DEI Work Through a Half-Credit Course

Contributed – Amy Lytle, Franklin & Marshall College

Many instructors are teaching about diversity, equity, and inclusion (or the lack thereof) in physics by integrating short curricular units into existing, high-enrollment introductory courses. While this approach is efficient and accessible, many students in this audience are not invested in a physics identity, which can limit the depth of its impact. As a complementary approach, I recently taught a half-credit, stand-alone course for Physics majors on Race, Gender, and Identity in Physics. With a small group of students deeply invested in the culture of the physics community, a relatively small time investment (six weekly 90-minute meetings, plus asynchronous reading and discussion) returned outcomes reaching far beyond the participants in the course. Discussions on barriers to success, as well as our own roles and responsibilities in changing the culture for the better, culminated in several student-led projects promoting inclusivity in significant ways in our department and institution.

PS.E-MO-10.02: Hertha Ayrton (1854-1923): Physicist, Inventor, Engineer and Suffragette

Contributed – William Palmer, Curtin University

Phoebe Sarah Marks was born on 28th April 1854 in Portsea, UK and was one of eight children. Sarah had a hard childhood but was very gifted and was helped by several benefactors. She attended Girton College, Cambridge studying mathematics; she passed her Tripos in 1880 but Cambridge did not award her a degree. While at Cambridge, she invented a sphygmomanometer. She obtained a London University degree a year later and began teaching. In 1884, she started a course on electricity at Finsbury Technical College, presented by Professor William Edward Ayrton; they were married a year later. Her career flourished and she made other valuable inventions. She was a committed suffragette. She died of blood-poisoning on 26th August 1923. It is now only two years to the centenary of her death, so we may expect to hear much more of her remarkable life in the near future.

PS.E-MO-10.03: Hispanics in Physics for Today's Students

Contributed – Karen Williams, East Central University

As a teen, I read biographies and mysteries. I loved reading about scientists, my favorite was book "Madame Curie" by Eve Curie. One of my happiest times was when I actually attended a talk by Marie Curie's granddaughter. I got to hear firsthand stories from the granddaughter who has two Nobel Prizes in the family! I currently direct an LSAMP program at my university where many students in the program are Hispanic. Do my students know of others in physics that look like them? Do they know their stories? Moreover, do the non-Hispanics in my department know about these persons? Do you? I will share the contents of a poster(s) that will reflect Hispanics in the physical sciences, particularly physics. Hispanic students should read about the lives of their role models in history and about those that are currently successful in the field.

PS.E-MO-10.04: Historical Flirtations with the Physics of the Paranormal

Contributed – David Kordahl, Centenary College of Louisiana

Many high-profile contemporary physicists have aligned themselves with paranormal skepticism, as espoused by organizations like the Committee for Skeptical Inquiry. Yet this attitude has not always been universal for physicists, nor do we need to reach back to the era of alchemy for counterexamples. In the modern era, we find prominent physicists who were members of the Society for Psychical Research, proponents of synchronicity and ESP, and believers in all manner of quantum spookiness. In this talk, I will review recent work from historians of science on the complex connections between experimental physics and paranormal belief, and argue that an appreciation of this history may help physicists to communicate their subject in a way that is more inclusive to diverse viewpoints.

PS.E-MO-10.05: The Uncelebrated Arab Genius

Contributed – Scott Bonham, Western Kentucky University

Whitewashing science goes back hundreds of years. An early victim was the medieval Arab scientist Ibn al-Haythem. His work combining experimental investigations with mathematical modeling anticipated by many centuries the rise of science in Europe, and his breakthrough theory of light and perception was the first to be both physically grounded and mathematically rigorous. In the late medieval period his theory of light and perception was adopted wholesale in Europe, influencing the development of Renaissance art and laying the foundations of modern geometric optics. In the process, however, his name and ethnic background were obscured—likely due to racial or religious prejudice—and even to this day he is not given due credit for the significant contributions he made to physics. In this talk I will briefly review his work and describe how it entered into European scholarship while he was personally denied due credit.

PS.E-MO-10.06: Importance of the Islamic Golden Age for Physics and Astronomy

Contributed – Joanna Behrman, American Institute of Physics

The Islamic Golden Age was a time of great cultural and intellectual exchange lasting from approximately the 8th to the 14th century, located in the Middle East, Northern Africa, and parts of Europe. This time period was also characterized by major developments in science and medicine. Even words like “algebra” and “algorithm” can trace their origins back to this period. However, the importance of this era to the development of modern science ought to be better known. This talk will cover some of the background history of the Islamic Golden Age as well as some of the major contributions in mechanics, optics, and astronomy.

PS.E-MO-10.07: Priming Young Scientists: Identity and Physics

Invited – Samantha Spytek, Rock Ridge High School, Loudoun County Public Schools

Diversity in physics remains low despite a social shift towards STEM inclusion. According to AIP’s Statistical Research Center, women have seen some increases in representation at the post-secondary level, however that has stagnated even with consistent, equitable participation in high school. Moreover, among underrepresented minority groups, less than 15% of all physical science bachelor degrees awarded in the US are to African-American or Latino/a individuals. After decades of work promoting STEM inclusion, why does this disparity remain? The answer may lie in our marketing, and how we as teachers not only sell the course, but the truth that anyone and everyone can belong. In this talk, we will use the following questions to guide our discussion. What is the current state of diversity in physics? What is identity and how do we define the self? How can teachers better prime their students to see themselves in science careers?

PS.E-MO-10.08: Handling Student Resistance When Teaching About Racial Microaggressions

Contributed – Erin De Pree, St. Mary's College of Maryland

When teaching about how to combat racial microaggressions with “micro-interventions,” some students will resist the idea that they somehow contribute to an overall social problem. I will discuss how reframing the problem into practicing interventions often dilutes these concerns and how to deal with problematic essays due after an in-class workshop. This is particularly helpful when dealing with students who try to use their essay to explain why the instructor is wrong or otherwise dodge the assignment.

PS.E-MO-10.09: Promoting Equity and Social Justice through Culturally Responsive Astronomy Education

Contributed – Christine O'Donnell, Arizona State University

Kimberly A Scott, Arizona State University

In recent years, addressing diversity, equity, and inclusion in STEM fields, including physics and astronomy, has received growing attention. To effectively promote equity and social justice, we need to acknowledge the role of oppression in disciplinary cultures and thus transform these cultures to be created by and for people of all identities and lived experiences. These actions will improve the teaching and learning of academic content. Here, we propose a culturally responsive framework for astronomy education that incorporates asset-building, reflection, and connectedness, and we present a sample curriculum created using this framework. Students learn astronomy content, such as about Solar System dynamics through physical modeling and simulations, as well as participate in discussions that problematize cultural norms and develop potential solutions. Our approach guides students to critically engage with the content and empowers them to become change agents for making astronomy equitable.

Session: PS.E-MO-11 Upper Division Undergraduate

Monday, August 2, 10–11:15 a.m. Sponsor: Committee on Physics in Undergraduate Education Presider: *TBA*

PS.E-MO-11.01: The Equations Match the Drawings: Geometric Algebra for Geometric Optics

Contributed – Theodore Corcovilos, Duquesne University, Pittsburgh, PA

Geometric optics is often taught (e.g. in Halliday, Resnick, and Walker) starting with light rays, jumping to imaging equations (where did that come from?), cascading the imaging equations, and then perhaps going back to ray tracing "by hand." All-in-all it is algebra salad that obscures the physics: light rays bend or reflect at surfaces, and where they intersect you get images. By using a better mathematical language, we can simplify things. Projective Geometric Algebra (PGA) gives a natural language for Geometric Optics. PGA builds upon Geometric Algebra (a real subset of Clifford Algebra, notably applied to physics by David Hestenes and others) by adding homogeneous coordinates. Planes, points, and lines become related by algebraic products with geometric meaning -- meets and joins -- making the equations match the drawings and simplifying calculations. Beyond this, techniques like ray transfer matrices gain new power, now working on points as well as rays.

PS.E-MO-11.02: Bringing the Physics Back into the Undergraduate Quantum Classroom*

Contributed – James Freericks, Georgetown University

Quantum mechanics instruction has remained unchanged for at least 75 years, following a coordinate-space-based formalism that requires significant class time for instruction on the mathematical background for the Frobenius method, delta functions, Fourier transforms, etc. This mathematics instruction, greatly limits the amount of physics that can be included. In this talk, I will tell you how to reverse this trend. In Fall 2020, I taught a one-semester quantum mechanics course at Georgetown that worked within a representation-independent formalism (emphasizing operators, not wavefunctions). It is mathematically simpler and frees up time for discussing conceptual and physical ideas. I discuss important experiments such as Stern-Gerlach, delayed choice, EPR, Bell inequality tests, Hong-Ou-Mandel, Pickering-Fowler lines, discovery of deuterium, proton radius, electron momentum spectroscopy, time of flight, hyperfine interactions and radio astronomy, cyclotron resonance and MRI, single-photon detection, homodyne detection, and LIGO. Come see how you can adopt this for your class too.

*Funded by National Science Foundation Grant Number PHY-1915130 and McDevitt Bequest at Georgetown

PS.E-MO-11.03: Improving Upper Division Homework Effectiveness

Contributed – R. Steven Turley, Brigham Young University

I will report on three practices I implemented in upper division electromagnetic theory courses to improve the impact of homework on student learning. The principal innovation was to adapt some of the principles of calibrated peer review, which has been demonstrated to be beneficial in writing assignments to common physics homework assignments. The other two innovations involved having the students complete the assignments using templates in Jupyter notebooks. This gave them an opportunity to present their homework in a professional manner and to check their symbolic answers against answer verification software running on a server. These innovations improved student persistence until mastery, encouraged students to study alternate approaches to problems, and increased the time students spent on analyzing what they did incorrectly on problems. I will report formal and informal feedback I received from students on the effectiveness of these innovations.

PS.E-MO-11.04: Online Tutorials for Middle-Division Quantum with Adaptive Guidance

Contributed – Giaco Corsiglia, University of Colorado, Boulder

Benjamin P Schermerhorn, Gina Passante, California State University, Fullerton

Homeyra Sadaghiani, California Polytechnic University Pomona

Steven Pollock, University of Colorado, Boulder

Research-based tutorials—worksheets that guide students in constructing physics knowledge for themselves---have repeatedly proven to be a highly effective complement to lectures in physics courses. Our collaboration has created a collection of tutorials for middle-division quantum mechanics (QM), which has been successfully adopted by QM instructors nationwide. However, many instructors lack the resources and/or institutional support to run tutorials; it can be difficult to find time, space, and personnel to facilitate these activities. As an alternative, we are developing online versions of our QM tutorials that students can work through without instructor facilitation. We are designing the online tutorials to guide students through the worksheets in ways that encourage sense-making and allow students to progress without revealing the answers. For example, they include adaptive guidance pathways based on students' responses. Early beta versions are available, for free, at acephysics.net.

PS.E-MO-11.05: A Knowledge-in-Use Assessment for Upper-Division Thermal Physics

Contributed – Katherine Rainey, University of Colorado Boulder

Amali Priyanka Jambuge, Amogh Sirnoorkar, James T Laverty, Kansas State University

Bethany R Wilcox, University of Colorado Boulder

Research-based assessments can provide instructors insights into the efficacy of their teaching and course transformations. As education shifts to focusing more on scientific practices and crosscutting concepts in addition to conceptual knowledge, there is a need for an assessment that can assess these 3-dimensions of learning and inform instructional approaches that foster this learning. In this talk, we present a first-look at an upper-division thermal physics assessment that explicitly targets scientific practices, crosscutting concepts, and conceptual knowledge using coupled, multiple-response items. We will present an example assessment item and discuss ways in which instructors can help with the development process of this assessment while incorporating it into their classrooms. Faculty administering the assessment would receive detailed feedback about their class's overall performance with recommendations for how to adjust instruction to improve student outcomes.

PS.E-MO-11.06: Physics Undergraduate Advanced Labs During Covid-19 Pandemic

Contributed – Pratheesh Jakkala, University of Cincinnati

This paper describes how the physics undergraduate advanced labs are handled during Fall 2020 in a covid-19 pandemic situation. There were 24 students enrolled in the class. Students were divided into two groups, three activities, four blocks of time, and a lab "sparring" partner. The advanced labs have a three-prong approach with each student performing one computational exercise, one socially distanced in-person standard labs, and a home-based project. Ipython/Jupyter Notebooks, Matlab was used for computational labs. The in-person labs were set up in four rooms of two different buildings to follow social distancing safety protocols. About 18 different home-based projects were "built" and analyzed by 24 students. Online weekly logbook reports were introduced for easy access and feedback. The advanced lab was highly successful with great student participation, engagement, learning with more than expected positive outcomes.

PS.E-MO-11.07: Rework and Recall: Exam Performance in Upper-division Electromagnetism

Contributed – Andrew Mason, University of Central Arkansas

John Colton, Brigham Young University

Jessica Martin, University of Idaho

We present preliminary mixed-methods results for an experiment upon a first-semester senior undergraduate electromagnetism course for physics majors, in which 25 students were given explicit incentive to rework mistakes from unit exams in a first-semester senior-level electromagnetism course. Three unit exam problems were revisited on the final exam. Initial quantitative results for one of the three problems (P1) showed a strong effect from unit exam to final, between students who reworked problems and students who chose not to; however, the other two problems (P2 and P3) presented a ceiling effect on unit exam performance that prevented pre-post analysis. Follow-up interviews with a small sample of students suggest a strong recall of their attempts on problems P1 and P2 despite being over a year removed from said exams; however, some did not recognize mistakes. We conclude by discussing plans for collection of future data and adjustments to this ongoing study.

PS.E-MO-11.09: Using Completeness Relations to Help Students Understand Wavefunctions

Contributed – Elizabeth Gire, Oregon State University

Corinne A. Manogue, Oregon State University

Maggie Greenwood

In order to help our students better understand the conceptual connections between spin states and wavefunctions in our junior-level, spins-first quantum course, we have recently begun to emphasize the use of completeness relations to write a state in a particular basis. We describe completeness relations as "special forms of 1" that can be used to project a quantum state vector onto a basis. Using a discrete spin bases, the expansion coefficients are interpreted as probabilities amplitudes. Using a continuous position basis, these probability amplitudes get "smeared out" to become a "probability amplitude density" (a.k.a., wavefunction), similar to how discrete point masses go to mass densities. In this talk, we will share the in-class activities and homework tasks we've developed to help students understand make these connections.

PS.E-MO-11.10: Reimagining Undergraduate Research in the Post Covid-19 era

Contributed – Sathya Guruswamy, University of California, Santa Barbara

Covid-19 has severely restricted undergraduate access to research labs since April 2020. Many REU programs and faculty adapted to the challenge by providing remote research projects in lieu of in-person research, and students showed remarkable resilience in adapting to remote work. In this talk, we discuss the limitations, the successes and the lessons learned from the past year and a half of remote research experiences. We discuss the inequities in the availability of paid research opportunities that was cast into much stronger relief during this period. We explore ideas to re-imagine undergraduate research and possible ways to expand research opportunities for undergraduates after Covid-19 restrictions are lifted.

Session PS.E-MO-12 Make Play Do Learn   Monday, August 2, 10–11:15 a.m.

Sponsor: Committee on Physics in Pre-High School Education   **Presiders:** *Nina Morley Daye, Alice Flarend*

Session: PS.E-MO-13 Effective Practices in Educational Technology II — Monday, August 2, 10–11:15 a.m.

Sponsor: AAPT **Presider:** *David Marasco*

PS.E-MO-13.01: Open and Individualized – Mechanics Homework Problems Project Using WeBWorK

Contributed – Jennifer Kirkey, Douglas College

Agnes d'Entremont, University of British Columbia

Individualized homework problems delivered over the web are an effective way for students to learn first year mechanics. This is not news, but I learned how effective it was and that it is worth spending the time developing more problems as part of an open community. WeBWorK is an open-source on-line homework system that gives students instant feedback. It has better quiz options than most Learning Management Systems. WeBWorK has been used by the mathematics community for decades, but there are not many physics problems in the Open Problem Library (OPL) and less than 100 of the type needed for first and second-year physics and engineering students. I am a physics instructor at a two-year teaching college, but I ended up working with an engineering professor and coop students at UBC, a large research university We hope to have more people join us in this worthwhile project.

PS.E-MO-13.02: A Remote Course on Acoustics for Non-science Majors

Contributed – Milind Kunchur, University of South Carolina

Getting non-science majors excited about science is not an easy task, especially with the remote-instruction paradigm forced by COVID. Since non-science majors may take only one science course, my Acoustics lecture and lab courses cover a diverse range of science topics affecting every aspect of sound and its perception (oscillators, waves, musicology, biology of the ear, auditory neuroscience, architectural acoustics, and electronics). A highly interactive remote platform was developed that allows students to see a montage that integrates a large-sized live view of the instructor, a paper & pencil “whiteboard”, and additional documents (Powerpoint, etc.), without switching between views. The instructor sees all student faces allowing him to call them by name to keep them engaged. The lecture material is reinforced by cool hands-on remote labs developed for students to do in their own space. Details of the labs will be covered in a separate poster.

PS.E-MO-13.03: Google Sites as a Platform for Student Lab Notebooks

Contributed – Kristen Thompson, Davidson College

In response to the shift from in-person to virtual learning, I have adopted Google Sites as a platform for connecting with students in my introductory physics and astronomy courses. In this talk, I will describe how students use Google Sites to introduce themselves to the instructor, provide updates about their successes and struggles, create and maintain a digital lab notebook, and build a portfolio of their work and learning. I have found this platform to be quite effective and students have responded well to the model. I therefore plan to continue using Google Sites extensively in my courses post-pandemic.

PS.E-MO-13.04: Video Versus Interactive Video for Impact on Learning*

Contributed – Kathleen Koenig, University of Cincinnati

Alexandru Maries, University of Cincinnati

Robert Teese, Michelle Chabot, Rochester Institute of Technology

With the rise of the flipped (active) classroom, in addition to more courses moving online, the use of video as a form of instruction has increased substantially. This raises the question about the impact of this method of delivery on student learning. Under NSF funding, we have developed and evaluated multiple interactive video-enhanced tutorials (IVETs). The IVETs involve web-based activities that lead students through a problem solution using expert-like problem-solving approaches. As part of the IVET evaluation, we assigned one group of students to complete the IVETs as homework, while another group watched a video summary of the problem solving process. Both groups later completed a follow-up problem as a means of measuring impact on learning. Significant learning gains were observed for students in the IVET group compared to the Video-only group. Results from multiple IVETs will be shared along with suggestions for making videos more mentally engaging for students.

*Work supported by the NSF IUSE Program (DUE #1821396)

PS.E-MO-13.05: Updating Mechanics Labs with Technology for the Pandemic and Beyond

Contributed – Andy Gavrin, Indiana Univ. Purdue Univ. Indianapolis (IUPUI)

When planning to take my calculus-based introduction to mechanics online, I had many small concerns, and two huge ones: tests and labs. In both cases, the solutions I found were imperfect, but contained elements that were improvements over the pre-pandemic versions. In this talk, I will focus on the labs. I replaced hands-on labs with a mixture of simulations, computational exercises and labs using the sensors in students’ smartphones. While many students missed the “lab group experience” they were excited by the additional flexibility afforded by these labs, particularly those using their phones. I will discuss the benefits and shortcomings of all three of these lab formats but focus primarily on the phone-based labs, which I will be continuing to use post-pandemic.

PS.E-MO-1.09: A Collaborative Approach to Designing an Introductory Computational Science Course

Contributed – Claudia Fracchiolla, University College Dublin

Maria Meehan, University College Dublin

Nowadays computation stands alongside theory and experiment as one of the pillars of modern science, which is reflected in the fact that research and industry rely heavily on technology and computation. Therefore, we need to prepare graduates to integrate computation within their underlying discipline. In this study, we look at how academics across the College of Science at an Irish University use computational practices in their research. This will inform the design of a first-year undergraduate science course aimed at emphasizing the relevance of computational practices in science, by introducing them to authentic problems across the areas of science where computation is used and to make students competitive graduates in their respective fields.

PS.E-MO-13.07: Computational Modeling & Video Analysis in One Easy Environment

Contributed – John Burk, Pivot Interactives

Computational modeling and video analysis are two powerful tools in the physics classroom for helping students analyze and model real-world phenomena. When we pair the two of these together in one web-based platform, students can use video analysis to construct a computational model that reproduces the data they measure from the video and gain new physical insights and understandings. Pivot interactives is one platform that allows for the integration of video analysis side by side with computational tools like Tychos, Glowscript, and Pyret.

AAPT AWARDS

Oersted Medal: Shirley Jackson

Presider: Chandralekha Singh

Physics: The River that Runs Through It All

President Shirley Ann Jackson of Rensselaer Polytechnic Institute will discuss her own educational path, which led her to a doctorate from MIT in theoretical elementary particle physics, and the ways that her research career in condensed matter physics expanded into government, corporate, and academic leadership roles at the highest national levels. She will consider "the Quiet Crisis", America's national need to bring women and underrepresented minorities into STEM fields in sufficient numbers, while continuing to attract talent from abroad. She will offer observations and ideas for the ways that the nation's physics teachers can help to bring the full talent pool into the field, as well as comment on the role of physics and physics-based education in creating a foundation for addressing complex global challenges – for individuals and collaborative groups.

Shirley Jackson

Monday, Aug. 2
11:30 a.m.–12:30 p.m.

AAPT AWARDS

Presider: Chandralekha Singh

Millikan Medal: Gregory E. Francis

Gregory Francis

Monday, August 2
1–2 p.m.

Two Red Bricks: Is A Good Lecture Better Than No Lecture At All?

It has been said that the typical lecture is every bit as effective as placing two red bricks in front of the class for fifty minutes. I have spent my teaching career trying to improve upon that baseline. I will discuss different techniques used in my large introductory algebra-based courses to make the lecture experience more active and student centered. I have found that using the lecture as a support platform built around the Tutorials in Introductory Physics by Lillian McDermott, Peter Shafer, and the Physics Education Group at University of Washington yields measurable gains in student conceptual understanding and retention.

Poster Session I: **Monday, August 2, 2:15–3:45 p.m.**
Sponsor: AAPT

Astronomy Posters

POS.A-MO.01: Web-browser based Projects in the Hybrid Introductory Astronomy Courses

Poster – Tatiana Krivosheev, Clayton State University

Dmitriy A Beznosko, Clayton State University

Teaching the introductory astronomy lecture and lab courses in the hybrid mode presents a challenge when it comes to the students' projects and experiments. As part of the ALG supported class transformation, the web browser-based tools using Java Script were developed to assist students in projects that they can carry out by themselves or in small groups at home following the provided project description or a simple lab manual. The projects include observation and plotting of the Moon position and phase, and Sun rotation using satellite images and others.

POS.A-MO.02: Activities for Visually Impaired Learners in Introductory Solar System Astronomy

Poster – Roger Hart, Community College of Rhode Island

Jessica Killian, Community College of Rhode Island

Core concepts in introductory solar system astronomy courses would be likely more difficult to master if the student has a learning disability. Visually impaired students may not be able to engage with astronomy course content if that content is presented in a visual format. Astronomy education research is underway to better integrate introductory astronomy learning objectives into materials to give visually impaired learners. However, limited activities have been initiated at the Community College of Rhode Island (CCRI). This project sought to develop a low-cost curriculum kit for visually impaired students based on content from ASTR 1010: The Solar System, using tactile, temperature, and sound techniques. These were developed and evaluated by both the instructor (Hart) and student (Killian). We show the facilitation of the learning objectives into tangible activities to give future visually impaired learners in the community college classroom setting a more engaging experience in Solar System Astronomy courses.

POS.A-MO.03: Comparing Two Scaffolds for Evaluating Scientific Explanations

Poster – Janelle Bailey, Temple University

Timothy G. Klavon, Doug Lombardi, University of Maryland-College Park

Archana Dobaria, Temple University

Our research lab developed the Model-Evidence Link (MEL) activities to support students' scientific evaluations and judgements when considering alternative explanations of phenomena. For the present study, we tested two astronomy-related MELs--the Moon Formation preconstructed MEL and the Origins of the Universe build-a-MEL--in high school and preservice teacher classrooms. Students engaged in both these activities, completing embedded measures of their evaluations, judgements, and knowledge, pre- and post-instruction. We asked: How do relations between students' evaluations, judgements, and knowledge compare between the preconstructed MEL and the build-a-MEL? Using a partial least squares structural equation model (SEM), we found that the preconstructed MEL had a stronger relationship between students' evaluations and post-instruction plausibility judgments, but overall SEM statistical indices showed that the build-a-MEL was more robust in promoting students' learning. Therefore, for the present study, the build-a-MEL was a better activity for facilitating more scientific evaluations, judgements, and astronomical knowledge.

POS.A-MO.04: Student Understanding of Eclipses: Then and Now

Poster – Katelin Brock, University of Georgia

Craig C. Wiegert, University of Georgia

Our research characterizes college students' understanding of eclipses and related phenomena. We initially gathered data from online and paper versions of a conceptual survey immediately prior to the August 2017 Great American Solar Eclipse. College students were asked basic questions about eclipses, such as the frequency of occurrence and the positions of celestial bodies, along with questions on prior instruction and demographics. Based on analysis of these initial results, we modified the survey for clarity and to include questions on student response confidence. We administered the survey again during the 2020-2021 academic year, and found that students performed significantly worse on the conceptual survey, especially on questions about the basic mechanism of eclipses. Since many of these students experienced the 2017 eclipse, this suggests that basic conceptual understanding of eclipses following media attention and/or classroom instruction is not retained.

Computer Modeling and Computation in Labs Posters **Monday, August 2, 2:15–3:45 p.m.**

Sponsor: Committee on Educational Technologies / Co-Sponsoring: Committee on Laboratories *Presider: Todd Zimmerman*

POS.B-MO.01: Chromaticity Simulation Using Software Program

Poster – Shihong MA, Department of Physics, Fudan University

Liang-cheng Zhou, Yi-fan Wang, Department of Physics, Fudan University

Chromaticity measurement is an interdisciplinary subject and is very complex. Color of object s could be measured accurately by using computer-software with the transmission spectra of grating spectrometer on the basis of the international standard, CIE-XYZ system. The colors can display directly on the computer screen. The experimental result s and theoretical analysis are presented in agreement also in this paper.

POS.B-MO.02: Introducing Computation and Modeling Experience through Brownian Motion Experiment

Poster – Tatiana Krivosheev, Clayton State University

Dmitriy A Beznosko, Clayton State University

We present our experience of using the study of Brownian Motion to expose students in the introductory physics laboratories to the computation and modeling. A sample of a Brownian motion is analyzed by using the Tracker video analysis and modeling tool and processed in the Jupyter electronic notebook. The Jupyter electronic notebooks enable us to run a two- and three- dimensional Mone Carlo simulation of Brownian Motion along with the statistical analysis of both the simulated and experimental data. The experiment is suitable for use in both calculus- and algebra-based sequence with the small modifications for the algebra-based students.

POS.B-MO.03: Radius of Earth from a Photo of Two Distant Bridges

Poster – Clinton Lewis, West Valley College (retired)

An unusual photograph through a telescope of two distant San Francisco bridges, one close, one far, shows the curvature of the Earth. The more distant bridge is clearly lower in the water of SF Bay. Measurements from this photo, bridge dimensions, and a few calculations result in a calculated radius of the Earth surprisingly accurate!

POS.B-MO.04: Improving Students' Conceptions Combining Computational Modeling and Real-world Data

Poster – Jannis Weber, Goethe University Frankfurt, Germany*

Thomas Wilhelm, Goethe University Frankfurt, Germany

Computational Modeling is seen as one of the three pillars of modern physics by many. Surprisingly, it is not mandatory in many German school curricula and thus, few physics teachers use it in class on a regular basis. To increase awareness of computational modeling in the local physics teacher community and to investigate the effects of the use of computational modeling in combination with real experiments on students, a science lab was created, that combines computational modeling with experiments and real-world data to tackle students' preconceptions in Newtonian dynamics using the software Newton-II. Students from 11th grade take part in the science lab after having discussed Newton's laws in school. The poster highlights the way in which computational modeling is combined with real-world data in four different experiments and the effect of the lab on, among others, students' conceptual understanding and preconceptions.

*Sponsor: Goethe University Frankfurt, Germany

POS.B-MO.05: Optimization of Two-phase Jet Impingement Cooling for High Power-Density Processors*

Poster – Ethan Zuo, Saratoga High School

AI-dedicated processors perform specific tasks more quickly than general-purpose CPU/GPU, but their heat output is much higher, fast approaching the practical limits of current cooling technologies. Innovative cooling technologies are needed to harness the full computing power of next generations of processors. The purpose of this research is to investigate the mechanisms of a two-phase jet impingement cooling solution that can dissipate high heat flux of high power-density processors. Computational (CFD) modeling was carried out to study the flow fields and heat transfer inside two-phase jet impingement cooling systems. The effects of jet orifices diameter, orifice-to-surface distance, and orifice quantity on heat flux were studied. CFD modeling was validated with published experimental results. Results indicated boiling is the dominant factor in two-phase jet impingement. The optimal orifice diameter promotes interjet boiling which leads to higher heat transfer coefficient. The maximum pressure drop is within the range of practical implementation.

*This research was funded by MIT THINK Scholars program.

POS.B-MO.06: Integrating Simulation and Experiment in the WKU University Physics Laboratory

Poster – Doug Harper, Western Kentucky University

Scott Bonham, Western Kentucky University

We have recently restructured our first semester University Physics Laboratory to emphasize comparison of experimental and modeling results throughout almost all the experiments. The students, who also use simulation to a certain degree in the lecture portion of the course with the Matter and Interactions curriculum, write vPython code at glowscript.org to describe the fundamental physics of the interactions studied in the experiments. Students are provided a starter code for each experiment that performs the heavy lifting of creating a scene that resembles the experiment and setting up graphs of important parameters. The students focus on coding the fundamental force relationships as well the equations that integrate force to obtain momentum and velocity to obtain position. They write reports that focus on comparisons between experimental results, modeling outcomes, and theoretical predictions. In this poster we will present examples of several experiments and models that are used in this laboratory.

POS.B-MO.07: Modern Physics Computation with Jupyter Notebooks

Poster – Troy Messina, Berea College

With the pandemic, comes teaching online or in blended modes of online and in-person. To adapt, I have designed labs with a stronger focus on computation than in the past. Some labs include data collection from videos or equipment that was sent to students at home. Other labs are purely computational. In this presentation, I will briefly present the labs and intended learning outcomes. A summary of anecdotal observations will be made. All Jupyter notebook materials will be made publicly available.

Integrating Computation During a Pandemic Posters **Monday, August 2, 2:15–3:45 p.m.**

POS.C-MO.01: Using Video Analysis to Perform Remote Experiments in Mechanics Laboratories

Poster – Tatiana Krivosheev, Clayton State University

Dmitriy A Beznosko, Clayton State University

Following the restructuring of many science classes and labs, teaching the introductory mechanics labs in hybrid mode (with a half of the students attending one lab session and other half attending next session) during Fall'20 and Spring'21 has provided valuable experience in integrating the computation into these courses. The poster will present the use of the Tracker Video Analysis and Modeling Tool for the exciting laboratory experiments in mechanics. The students had the opportunity to set-up and film some of the experiments themselves at home/dorm, and analyze the video yielding results of same or higher quality compared to those experiments done in lab (note that filming was optional as carefully set-up videos for analysis were provided).

POS.C-MO.02: Integrating Computational Jupyter Notebook Lessons into High School Physics

Poster – Enrique Arce-Larreta, Department of Defense STEM Ambassador

Jupyter Notebooks gaining popularity in Universities for scientific computation and programming. Jupyter Notebooks utilize Python programming and are primarily used to handle large data sets. They are also used in scientific computational projects, such as machine learning. Advantages for the educational setting include: it is free to use (with a google account), its enabled to be highly collaborative (like google docs), and has the ability to allow advanced code markup including writing equations, inserting hyperlinks, youtube videos and other media. I developed six Jupyter Notebook lessons introducing high school physics students to computational physics, aimed at teaching them to graph data and solve problems. The large data sets used included the open data repository from the CMS experiment at CERN, where students can access real data to discover a particle.

POS.C-MO.03: Computational Tasks for Intermediate Mechanics

Poster – Ernest Behringer, Eastern Michigan University

Students at Eastern Michigan University who have chosen a physics major or minor are now required to take a course introducing them to scientific computation. Nonetheless, they benefit from intentional and continued practice of newly developed computational skills. Such practice can readily occur in courses such as intermediate mechanics, where the content is more visual and less abstract. I will describe computational exercises used during Winter 2021 to provide students further experience with spreadsheets and GlowScript code. I will also discuss their implementation during virtual course meetings brought on by the global pandemic.

POS.C. SA.04: Entropy Change from Phase Transitions: Introducing Computation White Transitioning Online

Poster – Joshua Qualls, Morehead State University

Just prior to the global pandemic, Morehead State University newly joined the Partnership for Integration of Computation into Undergraduate Physics (PICUP) to better integrate computational ideas and techniques across the entire physics curriculum. So the transition overnight from in-person lectures and introducing computation to being completely virtual brought completely new and unexpected challenges; we were just beginning to integrate computation and would now have to teach this entirely new content remotely. Over the previous year, however, adapting to these challenges improved both the delivery of computational information and introduced new approaches and techniques that would otherwise not have been considered. We report on the successes and failures of our department as we integrated computation throughout introductory physics courses (including lecture and lab), engineering courses, and upper-level physics courses during a pandemic.

POS.C. SA.05 : Motion Analysis in Physics

Poster – David DeMuth, Valley City State University

Kelly Nelson, University of Minnesota, Crookston

An HTML5-based video motion analysis tool for the physics courses was developed as a vehicle to improve face-to-face and online instruction in laboratories and lectures, an effort motivated by the COVID-19 crisis. Students upload captured video from their cell phones to YouTube, then capture the motion frame by frame via a web browser to produce tabulated data suitable for import into Google Sheets or Excel when position, velocity, and acceleration versus time scatterplot graphs are created and analyzed. This project was funded by North Dakota EPSCoR #FAR0033914.

Labs/Apparatus Posters **Monday, August 2, 2:15–3:45 p.m.**

POS.D-MO.01: Demonstrator of Low Frequency Longitudinal Standing Wave

Poster – Xiangming Kong, Hebei University of Technology, Tianjin, P.R.China

Wenjiang Ye, Xuesong Duan, Jianhai Wu, Hebei University of Technology, Tianjin, P.R.China

The formation of standing wave is accompanied by the generation of wave node and wave abdomen. Different from the transverse standing wave, the longitudinal standing wave also has the thinning part and the dense part. Previous demonstrators of longitudinal standing waves were able to demonstrate these phenomena at a slightly higher frequency (~30Hz), which made it impossible to see how the phenomena changed in density. Except with the help of a strobe or high-speed photography, it would have been a mistake to assume that the wave nodes were and wave abdomens always in the thinning part and the dense part respectively. In this paper, a new demonstrator of the longitudinal standing wave is presented, which can clearly see the periodic density change at the nodes of longitudinal standing wave, the opposite density state at the adjacent node, and the maximum amplitude at wave abdomen with a relatively low frequency (~4Hz).

POS.D-MO.02: Projectile Motion Simulation, with a Low-Cost Interactive Arduino/S4A based Apparatus

Poster – Uriel Rivera, ITESM

An interactive low-cost simulation based on Arduino and S4A with a friendly graphical user interface (GUI) with the aim of easing the teaching/learning process of projectile motion, is presented. Parameters related to this motion such as launch angle, initial speed and height can be controlled with a joystick.

POS.D-MO.03: Teaching Physics by Inquiry Remotely

Poster – Jennifer Blue, Miami University

Donna Messina, University of Washington

*Physics by Inquiry (*McDermott et al, 1996)* is a hands-on, inquiry-based curriculum. Students work through the experiments and exercises in small groups, with their understanding assessed at pivotal points in the curriculum. During the COVID-19 pandemic, we taught Physics by Inquiry courses remotely, encountering the challenges of synchronous teaching and learning. This poster will illustrate our strategies and the ways we met the challenges.

* *Physics by Inquiry,* Volumes I and II, by Lillian McDermott, Peter S. Shaffer, and the Physics Education Group at the University of Washington (Wiley 1996).

POS.D-MO.04: Experiment Activity of Student Collaboration In Synchronous Distance Learning

Poster – Hyun Sook Choi, Jinseon Girls' High School

In this study, I present to introduce synchronous distance learning that allows experiment activity of student collaboration. The learning goal is to understand the exact pattern in the number of node lines, depending on the distance between two sound sources. The activity design and user tools are as follows: First, I used PhET's sound simulation to allow students to participate in a virtual lab activity on sound interference. Before joining this activity, each student prepares a ruler to measure the distance between the two sound sources shown on the computer monitor. Second, I provided students with direct demonstration to help students understand the experimental procedure using Zoom's Content from a 2nd Camera before starting the activity. Finally, Google Tools and Zoom's Breakout Room are used for collaborative interactions within each group online.

POS.D-MO.05: Diverse Strategies for Design Physics Activity by Investigating Research-based Activities

Poster – Amin Bayat Barooni, Georgia State University

Stephen Ross Scoular, Brian D. Thoms, Joshua S. Von Korff, Georgia State University

Additional Author : Jacquelyn J. Chini, University of Central Florida

To support physics instructors in improving or modifying physics activities for their courses, we investigate sixty-six research-based activities from eleven different research-based curricula by applying k-means cluster analysis. The best results were found when the program generates three design clusters. We mark these clusters as Thinking like a Scientist, Learning Concepts, and Scientific Reasoning. These three clusters indicate different design goals. In the Thinking like a Scientist cluster, activities emphasize the design of experiments by students, error analysis, reasonableness checking, and making assumptions or simplifications. The Learning Concepts cluster focuses on the prediction of results and experimental observations. The scientific reasoning cluster emphasizes answering physics or math questions that do not use collected data and finding evidence by students to support their claims.

POS.D-MO.06: Surface-Plasmon-Resonance Sensing in the Advanced Physics Laboratory

Poster – Eugenii Donev, Austin Peay State University

Alaa Adel Abdelhamid, The University of the South

We describe a suite of experiments and computations with an adjustable “challenge level” to engage upper-division undergraduate physics and engineering students for periods ranging from two laboratory sessions to semester-long research projects. The end product is a tunable optical sensor for differentiating between fluids with even tiny variations in refractive index: e.g., 1.332 for deionized water vs. 1.334 for 0.5 wt% saline solution. It revolves around a thin gold film on a glass prism coupled to a microfluidic cell. The surface-plasmon-resonance (SPR) phenomenon excited by the incident laser at the gold-fluid interface is exquisitely sensitive to subtle changes in the near-surface environment. Crucially, it also immerses students in the rich physics of metal nano-optics and evanescent waves, in constructing precision optofluidic setups, and in developing analytical (Fresnel equations) and numerical (e.g., finite-element method) computational models to aid in their understanding and engineering optimization of the SPR sensor.

POS.D-MO.07: Some Cool Hands-On Experiments for a Remote Acoustics Lab

Poster – Milind Kunchur, University of South Carolina*

Getting non-science majors excited about science is not an easy task. It is especially difficult to design remote experiments that they can perform with understanding and relate to fundamental principles. For this newly designed acoustics lab, all necessary equipment was shipped at a cost of ~$20/student. (A $1 earbud replaced the traditional single-frequency tuning fork, while providing the benefits of adjustable frequency and volume, and a sustained tone.) They study phenomena such as harmonic oscillators, Fourier synthesis/analysis, psychoacoustics, and various wave effects (interference, diffraction, resonance, etc.). They also learn sophisticated instrumentation (sweep generators, real-time analyzers, acoustic triggering, intensity profiling, etc.) thus bridging traditional physics experiments with modern technology and engineering. Having them conduct the labs in their own space ensures that every student participates fully, while avoiding the problem of picking up sound from the neighboring teams' apparatuses when 20 students are performing a sound related lab in one room.

*Sponsor: Don Franklin

POS.D-MO.08: Real-time 3D Object Tracking for High School and Undergraduate Physics

Poster – Lori Shaaban, Portland State University

Akash Prasad, Camas High School

Zane OthmanGomez, Vrushank Gunjur, Liberty High School

Ralf Widenhorn, Portland State University

Physics lab courses typically focus on analyzing one-dimensional data. Using two-dimensional setups can be time consuming and introduce parallax errors. While one-dimensional data collection is adequate for linear motion, it is now possible to quantitatively analyze more complex systems by setting up a 3D camera. At Portland State University we worked with a group of high school students to develop a python program that tracks and graphs objects in real-time in three dimensions using a Intel RealSense D435i camera system. We created a mix of data analysis challenges and laboratory investigations designed to synthesize student's prior skills and concept knowledge as well as explore the nature of new situations through kinesthetic learning and optional programming. The poster will describe a set of activities analyzing projectiles as well as a ball on a string moving in a 3D space outside a single plane with a focus on momentum and rotations.

POS.D-MO.09: Oscillations and Hooks Law for Fully Remote Introductory Physics Labs

Poster – Michael Nichols, Marquette University

To keep our introductory physics labs running during the pandemic, especially the Summer 2020 term, it became necessary to develop a set of labs to run for students while fully remote. Over the next three semesters many labs were developed for this reason or as a back-up to the hybrid lab. An Oscillations and Hooks law lab is one lab that has been tested as an effective means of translating the Lab to a version that can be done at home. Using an iOLab sensor device and some common household materials the lab serves as a good way to adapt a standard lab into one that is fully remote.

POS.D-MO.10: How Agency and Lab Reports Affected Attitudes in Remote Labs

Poster – Nathan Powers, Brigham Young University

Carsen Lindorff, Amber Hawkins, Daniel Boyd, Brigham Young University

In the switch to remote instruction at the start of the pandemic, we built off of a framework introduced by Abigail Mechtenberg at the University of Notre Dame. Students could choose whether to conduct an experiment from the lab manual used for in-person instruction or to deviate from that manual and conduct their own investigation. At the conclusion of each experiment, the students submitted a formal lab report. Instructional resources focused on supporting students on developing hypotheses, designing experiment, and on analyzing, interpreting, and communicating their results. An assessment of student attitudes, measured with the E-CLASS, showed a greater shift toward expert-like attitudes than we had previously measured for non-majors labs before the pandemic. We discuss the results and what we learned about using agency and lab reports to direct student focus toward constructing knowledge.

POS.E-MO.01: Exploring Ways to Make a Remote Physics Classroom More Inclusive

Poster – Merideth Frey, Sarah Lawrence College

In support of movements like Black Lives Matter, #ShutdownAcademia, and #ShutdownSTEM, I knew I needed to address social justice issues in my introductory physics classroom as well as increase my efforts to ensure a safe, equitable, and inclusive space for my undergraduate students. Due to the ongoing pandemic, these changes would need to happen in a primarily remote learning environment. This poster will explore the strategies and technology I utilized over the past academic year to create a more supportive, accessible, and inclusive remote learning environment for my calculus-based introductory physics courses. I will be sharing feedback from students and results of formal assessments looking at changes in students' science identity responses over the course of the year. I will also share my thoughts regarding how a well-designed remote learning environment may provide even more productive discussions on tough topics such as social justice than similar in-person environments.

POS.E-MO.02: Group Activities to Synthesize Physics Understanding

Poster – Matthew Olmstead, King's College

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

POS.E-MO.03: Material Development for Teaching Electric Circuits with the Pressure Analogy

Poster – Thomas Weatherby, Goethe-Universität Frankfurt am Main

Jan-Philipp Burde, Universität Tübingen

Thomas Wilhelm, Goethe-Universität Frankfurt am Main

The abstract nature of electricity makes it a particularly difficult subject for learners to form scientific understandings of the core concepts. One possibility of making such abstract concepts more accessible is using analogical teaching methods. In light of this, a syllabus was developed focusing on the analogy between the movement of charge due to potential difference and the movement of air due to pressure difference. Trials of this syllabus in German grammar schools show a significant improvement in learning gains when compared with traditional approaches. Learners' qualitative understanding is scaffolded using helpful language, color-coding the electric potential and links to familiar, everyday experiences. The materials used in the previous study have been translated into English and adjusted for use in public schools. Furthermore, additional materials to help structure lessons for less experienced and non-subject-specialist teaching staff are included in lesson packs. All materials will be made available free of charge.

POS.E-MO.04: Real-world Problems for AP® Physics 1 and AP® Physics 2

Poster – Eric Strong, Dallas Independent School District, Dallas, TX

Breaking free from the traditional "cart on a ramp" problem, this session presents a variety of real-world, aviation related, physics-based problems. Focused on the general aviation aircraft, both single-engine and multi-engine, the problems expose the student to application of physics in aviation. The problems span a range of difficulties from simple trigonometry and simple unit conversion problems to more complicated thermodynamic and forces on an airplane problem. The problems come from the aviation world, including examples from aircraft instrument approaches, aircraft turbocharger operations, aircraft drag force in various flying configurations, and asymmetrical thrust in multi-engine airplanes. These problems are targeted to the student in a first year, algebra-based physics course such as AP® Physics 1 and AP® Physics 2.

POS.E-MO.05: Supporting Gender-Equity in the STEM Classroom

Poster – Lynn Jorgensen, Gilbert High School

While the fields of science, technology, engineering, and mathematics (STEM) have grown in the past twenty years, the proportion of women in these fields has not seen the same growth. This article researches how inquiry-based instructional approaches can better support gender-equity in classrooms. It will look at the effects that confidence, group work, and Socratic questioning have on women in STEM courses, and how small changes in instruction can have large impacts on the experiences women have in STEM courses.

POS.E-MO.06: Bernoulli's Equation and Continuity Equation in terms of Energy/Mass Conservation

Poster – A. Tabor-Morris, Georgian Court University

This poster (1 of 2) demonstrates a spiral teaching technique, here how Bernoulli's Equation which is scaled per volume and the Continuity Equation scaled per time can be viewed, respectively, in terms of the Conservation of Energy and Mass and presented to students in a way that reinforces concepts and these laws of physics. Potential confusions and helpful hints are highlighted. This poster builds on the oral presentation "Spiraling Conservation of Energy/Mass in Introductory Physics: Kirchhoff to Bernoulli" also at this conference.

POS.E-MO.07: Kirchhoff's Laws of Electricity in terms of Conservation of Energy/Mass

Poster – A. Tabor-Morris, Georgian Court University

Showcased here (1 of 2 posters) are the details of Kirchhoff's two Laws of Electricity presented via spiral teaching in terms of voltage loops which are scaled per charge and current splitting scaled per time as, respectively, applications of the Conservation of Energy and Mass to students in a way that emphasizes these concepts and further buttresses these laws of physics as universal. Possible student misunderstandings and updated useful suggestions for teachers are included. This poster builds on the oral presentation "Spiraling Conservation of Energy/Mass in Introductory Physics: Kirchhoff to Bernoulli" also at this conference.

POS.E-MO.08: Bringing New Life to Open World Physics Lab Experiments

Poster – Chathuri Silva, University of Missouri St. Louis

Matthew Wentzel-Long, Kevin Renick, Steven D Tyler, Philip Fraundorf, University of Missouri St. Louis

In this paper we offer updated versions of two 1970's-vintage open world experiments (one on acceleration, and the other on Poisson statistics). We the discuss prospects for expanding these to a wider range of topics, as well as some of the challenges and opportunities for giving students a more active role in experimental design, and scientific reporting, with help from now widely available electronic technologies.

Other Posters **Monday, August 2, 2:15–3:45 p.m.**

POS.G-MO.01: STEM Attrition at a Military Academy: Cadets' Experiences and Recommendations*

Poster – Daniel O'Keefe, Center for Physics Education Research, Department of Physics, United States Air Force Academy, CO 80840

Jorge Valentine-Rodriguez, STEM Education and CTE Programs, Puerto Rico Science, Technology & Research Trust, San Juan, PR 00936

Wilson Gonzalez-Espada, Department of Physics, Earth Science and Space Systems Engineering, Morehead State University, Morehead, KY 40351

David Meier, Lachlan Belcher, Center for Physics Education Research, Department of Physics, 2354 Fairchild Drive United States Air Force Academy, CO 80840

Many students who enter college wanting to major in STEM, particularly females and members from underrepresented groups, end up switching to non-STEM majors. At the U.S. Air Force Academy, specifically, previous studies have uncovered that, despite a strong academic preparation, of the cadets who reported their intention to complete a STEM degree as incoming freshmen, 36.4% graduated in a non-STEM discipline, with quantitative classes (Calculus-based Physics, Calculus I, Chemistry I) pinpointed by the data analysis as gateways. In this follow-up study (Year 3), data from (a) the Registrar's Office and (b) a survey completed by 500 undeclared cadets and 1,000 cadets who are pursuing non-STEM majors, were analyzed to identify factors associated with STEM attrition, a starting point for the conceptualization of strategies to address it at the U.S. Air Force Academy and in Puerto Rican universities.

*DISTRIBUTION STATEMENT A: Approved for public release: distribution unlimited, PA#: USAFA-DF-2021-100.

POS.G-MO.02: STEM MILES: Mentoring Innovative Learning Experiences for Students

Poster – Leon Hsu, Santa Rosa Junior College

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 low-income, high-achieving STEM students. The program provides students not only with financial aid but also a cohort experience with like-minded peers, an SRJC faculty mentor, and workshops and a one-unit class to build career skills. The original plan was to enroll students in cohorts of 20 for up to three years before transferring to a four-year degree granting institution. Now in the third year of the five-year grant, we will discuss the outcomes and challenges of this program so far. This work was partially supported by NSF-1742635 and by Santa Rosa Junior College.

POS.G-MO.03: Two Content Pathways in Presenting Electromagnetism in Introductory Physics Textbooks

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

Guang Zeng, Texas A&M University-Corpus Christi

Vector cross products play a fundamental role in determining the directions of electromagnetism in introductory physics courses. After examining thirteen introductory algebra-based physics textbooks, we found authors adopt the following two content pathways in presenting the electromagnetic phenomena: Over 90% of the textbooks follow pathway one which presents only algebraic formulas and mnemonic techniques for right- and left-hand rules. Scarcely few follow pathway two, which presents vector cross products as a mathematical model and reinforces this model by presenting the specific cross product formula for each electromagnetic phenomenon. Physics instructors teaching college physics courses similarly present electromagnetism using these two content pathways. In light of Bloom's taxonomy of educa- tional objectives and constructivist learning theory, we recommend the second pathway.

POS.E-MO.04: Do Students Actually Use the Textbook?

Poster – Sarah Trallero, University of Connecticut

With the increasing cost of textbooks, a survey taken at the University of Connecticut questions how much undergraduate students actually use or do not use recommended textbooks in their physics courses. What percentage of students even obtain a textbook? How many students find textbooks to be an effective method for learning/studying?

Physics Education Research I Posters **Monday, August 2, 2:15–3:45 p.m.**

POS.F-MO.01: Student Understanding of Quantum Mechanical Observables and Corresponding Operators

Poster – Chandralekha Singh, University of Pittsburgh

Emily Marshman, University of Pittsburgh

Here we focus on an investigation that suggests that, even though Dirac notation is used extensively, many advanced undergraduate and Ph.D. students in physics have difficulty expressing the identity operator and other Hermitian operators corresponding to physical observables in Dirac notation. We first describe the difficulties students have with expressing the identity operator and other Hermitian operators corresponding to observables in Dirac notation. We then discuss how the difficulties found via written surveys and individual interviews were used as a guide in the development and validation of a Quantum Interactive Learning Tutorial (QuILT) to help students develop a good grasp of these concepts. We also discuss the effectiveness of the QuILT based on in-class evaluations. We thank the National Science Foundation for support.

POS.F-MO.02: Quantum Interactive Learning Tutorial on Larmor Precession of Spin

Poster – Chandralekha Singh, University of Pittsburgh

Additional Author : Ben Brown, University of Pittsburgh

We conducted research on student difficulties and used it as a guide to develop, validate and evaluate a quantum interactive learning tutorial (QuILT) on Larmor precession of spin to help students learn about time-dependence of expectation values in quantum mechanics. The QuILT builds on students' prior knowledge and strives to help them develop a good knowledge structure of relevant concepts. It adapts visualization tools to help students develop intuition about these topics and focuses on helping students integrate qualitative and quantitative understanding. Here, we summarize the development, validation and in-class evaluation. We thank the National Science Foundation for support.

POS.F-MO.03: Quantum Interactive Learning Tutorial on Quantum Key Distribution

Poster – Chandralekha Singh, University of Pittsburgh

Seth Thomas, University of Pittsburgh

We describe the development, validation and in-class evaluation of a Quantum Interactive Learning Tutorial (QuILT) on quantum key distribution, a context which involves an exciting application of quantum mechanics. The protocol used in the QuILT uses single photons with non-orthogonal polarization states to generate a random shared key over a public channel for encrypting and decrypting information. The QuILT strives to help upper-level undergraduate students learn quantum mechanics using a simple two state system. It actively engages students in the learning process and helps them build links between the formalism and the conceptual aspects of quantum physics without compromising the technical content. The in-class evaluation suggests that the validated QuILT is helpful in improving students' understanding of relevant concepts. We thank the National Science Foundation for support.

POS.F-MO.04: Just-in-Time Teaching and Peer Instruction in a Quantum Mechanics Course

Poster – Chandralekha Singh, University of Pittsburgh

Ryan Sayer, Benidji State University

Emily Marshman, 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 continuing feedback from students. We investigated the effectiveness of a JiTT approach, which included in-class concept tests using clickers in an upper-division quantum mechanics course. We analyzed student performance on pre-lecture reading quizzes, in-class clicker questions answered individually, and clicker questions answered after group discussion, and compared those performances with open-ended retention quizzes administered after all instructional activities on the same concepts. In general, compared to the reading quizzes, student performance improved when individual clicker questions were posed after lectures that focused on student difficulties found via electronic feedback. The performance on the clicker questions after group discussion following individual clicker question responses also showed improvement. We discuss some possible reasons for improved performance at various stages. We thank the National Science Foundation for support.

POS.F-MO.07: Network Analysis of the CLASS

Poster – Christopher Wheatley, West Virginia University

Elaine Christman, John Stewart, West Virginia University

Modified Module Analysis (MMA) has proven to be a productive method for studying physics conceptual inventories. MMA can be used to analyze large datasets by forming networks of item responses then using community detection algorithms to identify responses that are consistently selected together. MMA has been applied to many physics instruments, such as the Force Concept Inventory, identifying underlying misconceptions measured by the instrument and providing insight into the structure of those misconceptions. In this study, MMA was applied to over 8000 pretest and post-test responses to the Colorado Learning Attitudes about Science Survey (CLASS). The CLASS was separated into "expert-like" and "unexpert-like" responses, corresponding to the responses that were chosen by experts in physics. The communities present in the networks naturally separated into expert-like and unexpert-like communities. These communities were analyzed to determine coherent structure in the instrument and in students' attitudes about science.

POS.F-MO.08: Seeing Whiteness in Introductory Physics: A Case Study*

Poster – Amy Robertson, Seattle Pacific University

Wilford T. Hairston, Equitable Development LLC

Within whiteness, the organization of social life is in terms of a center and margins that are based on dominance, control, and a transcendent figure that is consistently and structurally ascribed value over and above other figures. In this poster, we draw on frameworks from Critical Whiteness Studies to make whiteness visible in an interaction from an introductory physics course, and we identify some of the tools, practices, and disciplinary values that reify and reconstitute whiteness in this interaction.

*This work was supported in part by National Science Foundation Grant Number 1760761; the opinions stated in this poster are our own.

POS.F-MO.09: How the Learning Environment Predicts Students' Motivational Beliefs in Physics

Poster – Sonja Cwik, University of Pittsburgh

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.

POS.F-MO.10: Life and Career Planning of Undergraduate Students after Graduation

Poster – Hien Khong, Kansas State University

Eleanor C Sayre, Kansas State University

This study explores how physics undergrad students envision their future selves after graduation. We interviewed physics students at an urban US masters-granting institution to examine how students develop their career planning, and what supports and impacts students to plan their careers. This work is situated within the context of future selves interacting with past and current selves. We employ possible selves theory to explain the mechanism behind students' career planning. This poster presents two case studies: Ricky and Francisco. We found that students' perceptions of careers go beyond what students have learned from class. Not only do academic experiences (engagement in research, engagement in extracurricular activities such as conferences) impact students' career choices, so do social experiences (lifestyle, social identity). Our findings can be useful for curriculum developers aiming to improve undergrad programs and support undergrad students to have fulfilling careers in their futures.

POS.F-MO.11: How Perception of Learning Environment Predicts Students' Physics Motivational Characteristics

Poster – Yangqiuting Li, University of Pittsburgh

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 the perception of learning environment shapes these motivational beliefs of women and men. Therefore, we conducted a study to investigate how the perception 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.

POS.F-MO.12: Who Do Students Believe a Growth Mindset Applies to?

Poster – Alysa Malespina, University of Pittsburgh

Christian Schunn, University of Pittsburgh

Chandralekha Singh

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.

POS.F-MO.13: Observing and Characterizing a Two-Year College Research Methods Course

Poster – Laura Wood, Michigan State University

Vashti Sawtelle, Michigan State University

Many two-year college (TYC) faculty have the opportunity to support their students through close student-teacher relationships due to small class sizes. We studied one such class in a cohort program at a TYC for natural science majors intending to transfer to four-year institutions. This course covered research methods for science, technology, engineering, and math (STEM) that we observed by taking field notes, administering written journal reflections to the students throughout the course, and by interviewing some of the students at the end of the course using a LifeGrid methodology. In this poster, we will discuss the course overall and the student experiences, as well as the ways our observational methods helped us build helpful research relationships.

POS.F-MO.14: Developing Essential Physics Skills through a Workshop-style Course

Poster – Joseph Kozminski, Lewis University

Christopher White, Lewis University

We have developed a workshop, which meets weekly in an online synchronous format, to support physics majors during the pandemic and to help them develop essential transferrable skills. Class typically begins with a check in to see how students are coping with the challenges of college during the pandemic. The rest of the time is spent on activities and discussions designed to help students develop communication and problem-solving skills, such as communicating science to the public and tackling open-ended problems, that are not commonly addressed elsewhere in the curriculum. There is flexibility built into the class such that we can adapt the schedule to meet the needs of the students or to go into more depth on certain topics. This poster will discuss the workshop format and activities as well as student feedback on the workshop and the potential for incorporating such a course into the physics curriculum.

POS.F-MO.15: Society's Educational Debts from Racism and Sexism in Science Disciplines

Poster – Jayson Nissen, Nissen Education Research and Design

Ben Van Dusen, Iowa State University

Hannah Huvard, University of Colorado Denver

Mollee Schultz, Texas State University

Robert Talbot, University of Colorado Denver

Professional societies call on their members to support diversity, equity, and inclusion. To meet this goal, introductory college courses need to repay the educational debts society owes due to racism and sexism. We investigated the size of and changes in society's educational debts in conceptual knowledge in introductory chemistry, biology, and physics courses for majors using a critical quantitative framework. The varying gender and racial representation across these disciplines provided context for interpreting the relationship between society's educational debts and representation across disciplines. We analyzed data from 22,520 students in 328 courses at 34 institutions collected with the LASSO platform using Bayesian hierarchical linear models. The models identified similar trends in educational debts due to racism and sexism in all three disciplines. We will discuss implications for research, instruction, and diversity in physics.

POS.F-MO.16: How STEM Faculty Enter Discipline-based Education Research

Poster – Christopher Hass, Kansas State University

Eleanor C Sayre, Kansas State University

Emilie Hancock, Central Washington University

Sam Wilson, Hancock

DBER requires a mastery of quantitative, qualitative, and/or mixed methodologies, and also a nuanced understanding of breadth of topic, research questions, and theoretical frameworks. This interdisciplinarity is particularly challenging for emerging DBER researchers who often switch into DBER with only discipline-specific content and research training. We are conducting a large study about how STEM faculty become involved with discipline based education research (DBER). Part of this study involved interviewing physics and math faculty about their perspectives on and pathways into DBER. Our primary goal was to identify the wants and needs of emerging DBER faculty. This poster discusses findings from our interviews with emerging DBER faculty. Using the Reasoned Action Approach developed by Fishbein and Ajzen, we focus on how faculty's experiences shape their beliefs about DBER within 3 categories: behavioral beliefs (and attitude toward the behavior), normative beliefs (and perceived norms), and control beliefs (and perceived behavioral control).

POS.F-MO.17: How Modeling Informs Students' Engagement in Sensemaking

Poster – Amogh Sirnoorkar, Kansas State University

Paul Bergeron, Michigan State University

James T Laverty, Kansas State University

Sensemaking– the process of generating new knowledge by ascertaining the underlying mechanism of a phenomenon– should be an integral part of students' academic experience. In this work, we highlight an introductory physics student's sensemaking on a physics problem through the framework of sensemaking epistemic game. The analysis of the student's approach across the four stages of the epistemic game reflects modeling of the problem context guided by a diagram. The process of modeling is found to involve three components: (i) denoting the physical entities (forces) through symbols, (ii) establishing the mathematical relationships between these symbols and (iii) inferring the physical meaning of the obtained relations. Through this observation, we argue that sensemaking involves engaging with all the three components of modeling. We also note the implication of this study on designing tasks that have the potential to nudge students towards engaging in sensemaking.

POS.F-MO.18: What Factors Predict FMCE Post-test Scores Controlling for Pretest Scores?

Poster – Dona Hewagallage, West Virginia University

John C Stewart, West Virginia University

This study reports the predictive power of different parameters towards FMCE (Force and Motion Conceptual Evaluation) post-test scores controlling for FMCE pretest scores. The sample consists of students (N=1060) from a large eastern land-grant university enrolled in Physics 1 (calculus-based mechanics class). These students are primarily pursuing engineering degrees. Multiple linear regression was used with FMCE post-test score as the dependent variable and a broad collection of independent variables including high school GPA, ACT/SAT score, college math entry level, AP classes taken, transfer credits, college credits, self-efficacy, sense of belonging, and personality. The degree to which these variables are still important if FMCE pretest scores are controlled for is examined.

POS.F-MO.19: Embracing Subjectivity in Physics to Support Student Empowerment

Poster – Andrea Wooley, Western Washington University

Randeep Basara, Seattle University

Abigail R Daane, South Seattle College

Descriptions of the Nature of Science are in contrast with the idea that physics is objective, unaffected by human influence. To better understand students' thinking about the nature of physics, we taught a lesson from the Underrepresentation Curriculum and collected written responses to the question, "Do you think physics is objective or subjective?" before and after in-class discussion. In this presentation, we share student responses about the presence of subjectivity in physics and relate them to commonly accepted ideas about the Nature of Science. Prior to discussing subjectivity, students tend to describe physics without reference to human influence. Afterwards, many students acknowledge the influence of human interpretation, biases, and values on physics. Some students also consider our understanding of physics as incomplete. These discussions are a first step towards increasing the awareness of structural and individual subjectivity. We believe this will ultimately support a more equitable, robust scientific community.

POS.F-MO.20: Knowledge Statements as a Productive Intervention to Prompt Reflective Thinking

Poster – John Kelly, Tennessee State University

Dual Process Theories of Reasoning (DPTOR) state that cognition has two major processes: a fast, automatic process (heuristic) and a slow, reflective process (analytic). A common heuristic among introductory physics students is that acceleration and velocity are the same thing. This heuristic has proved resilient to instruction in the author's classes. In a Conceptual Physics class, multiple choice questions on free fall were combined with a set of knowledge statements designed to trigger the analytic process. Students chose if each knowledge statement was helpful, unhelpful, or wrong in the context of the problem. Data suggest that the inclusion of the knowledge statements served as a productive intervention for engaging the analytic process. Student performance improved compared to the population that were not served the knowledge statements. An analysis of question time stamps was also performed to examine what proportion of students changed answers after viewing the knowledge statements.

POS.F-MO.21: Student Resources for Understanding Momentum*

Poster – Brynna Hansen, Seattle Pacific University - Seattle, WA

Lauren C. Bauman, University of Washington

Mikayla K. Valentin, Yohnannes M. Abraham, Amy D. Robertson, Seattle Pacific University

Much existing physics education research (PER) on student ideas about momentum focuses on the difficulties that students face when learning this topic. These difficulties are framed as obstacles for students to overcome in order to develop correct understandings of physics. Our research takes a resources-oriented approach to analyzing student responses to momentum questions, viewing student ideas as valuable and potentially productive for learning, over and above correctness. In this poster, we highlight four conceptual resources that provide insight into students' ideas about momentum. These resources are context-dependent, and can be elicited and built on by instructors to support students in developing more complex and sophisticated understandings of physics.

*Supported by NSF Grants No. 1914603 and 1914572

POS.F-MO.23: Exploring Student Conceptual Resources About Heat and Temperature*

Poster – Yohannes Abraham, Seattle Pacific University

Mikayla K Valentin, Brynna Hansen, Lauren C Bauman, Seattle Pacific University

Amy D Robertson, University of Washington

Previous literature about students' understanding of heat and temperature emphasizes students' misunderstandings of canonical physics concepts. In our study, we used a resources-oriented approach to analyze data from 653 students' responses to questions about thermal phenomena, highlighting ways in which their responses could serve valuable resources for continued learning. We categorized our findings into four common conceptual resources. These resources can be used to strengthen teaching methods by using students' understanding of heat and temperature, to foster their learning processes and help them to develop more advanced physics ideas.

*Supported by NSF Grants No. 1914603 and 1914572.

POS.F-MO.24: Experiment of Model Train using Ultrasonic Sensor Connected to Smartphone

Poster – Akira Adachi, Kanagawa Institute of Technology

A model train is automatically controlled for and physics experiments conducted by analyzing its motion. By measuring the motion of this model train using an mobile ultrasonic sensor unit (web site [1]) connected to a smartphone, live-time plots of distance, velocity, and acceleration can be obtained. This material will assist students in redefining their interpretation of physical experiences. Furthermore, programming the motion of a model train can be applied not only to physics education, but also to elementary and electronic work training[2].

[1] Moblie Physics Education Lab (Web site): https://sites.google.com/view/diracma888/

[2] A. Adachi: "New Physics Experiments using Model Train and Smartphone Apps: (Volume 1 Constant-Velocity Motion)" (e-books, 2021) https://www.amazon.com/dp/B08YD15NZX

POS.F-MO.25: Network Analysis of Collaboration in Upper-Division Remote and Hybrid Courses

Poster – Nathan Crossette, University of Colorado Boulder

Michael Vignal, Bethany R Wilcox, University of Colorado Boulder

Interactions and collaborations between individuals in a group can be represented with a social network. A social network is a mathematical graph with individuals represented as nodes which have connections, possibly of different strengths, to other nodes via edges. In prior work before the COVID-19 Pandemic, networks of student collaboration on homework assignments have been studied in the context of in-person courses. This research found that students' scores on homework and exams correlated with several nodal attributes including centrality and disparity measures. Respectively, these quantities reflect the 'closeness' of a node to the other nodes in the network and the distribution of the strengths of connections of a node to its nearest neighbors. We analyze student collaboration data from remote and hybrid courses and compare the student collaboration networks to those from in-person courses with the goal of understanding how various online learning modalities can impact student collaboration and performance.

POS.F-MO.26: Growth of Emerging Education Researchers in Virtual Professional Development Program

Poster – Shams El-Adawy, Kansas State University

Eleanor C. Sayre, Kansas State University

Faculty and graduate students develop as education researchers through different avenues. One possible path is through their participation in the Professional development for Emerging Education Researchers (PEER) program, which is designed to develop participants' discipline-based education research through hands-on activities during a series of workshops. We collected data before and during participation in one of the editions of this program conducted entirely online with primarily physics and math faculty. This data allows us to examine in what ways engagement in the workshops affects participants' research ideas and their self-efficacy. In particular, we explore the ways in which participants' perception of their growth in the field evolves as they engage in this professional development program. This work will enable us to analyze the impact of this virtual professional development experience as well as gain a deeper understanding of different facets of emerging education researchers' professional development.

POS.F-MO.27: Not Quite Face to Face: Conducting Qualitative Phenomengraphic Interviews Virtually

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

Ian Coburn, Jason Jun, Dawn Meredith, University of New Hampshire

As part of the development of the Fluids Conceptional Evaluation, we planned to conduct qualitative phenomenographic interviews in person with 10 students each from 14 different types of institutions from around the country. The purpose of these interviews was to 1) Establish of the clarity of each proposed FCE item; 2) Establish the appropriateness of graphics if any used with each proposed item, and 3) Determine the different reasons students selected particular responses to each item. When we received funding from the NSF for this project in Fall 2020, we were asked to address how we would adjust our methodology to conduct our research in the day of Covid 19. We quickly realized we had to switch our in-person interviews to Zoom virtual interviews. In this poster, we will describe how we were able to make this adjustment and the unexpected benefits and limitations of conducting interviews virtually.

POS.F-MO.28: Using Ranking Questions to Assess Student Assistants' PCK-Q*

Poster – Kerina Joyles,[1] Texas Tech University

Weston K. Wegleitner, Beth Thacker, Texas Tech University

As part of a project to develop a written instrument for assessing student assistants' (SAs') pedagogical content knowledge (PCK) in the context of questioning (PCK-Q), we are experimenting with questions in a ranking format. Previously, we have developed and validated questions in free-response format. We are now using those questions as the basis for ranking questions. Ranking questions are beneficial because they require the SAs' to evaluate potential SA responses to students in classroom scenarios and scoring can be automated. The instrument would examine a SA's ability to identify appropriate responses that provide evidence of the application of PCK-Q in the classroom. The poster will include the process of problem development, sample problems, and outline future plans regarding validation, reliability testing, and dissemination efforts.

1. Sponsor: Beth Thacker

* Funded by NSF IUSE Grant# 1838339 Measuring and Improving Pedagogical Content Knowledge of Student Assistants in Introductory Physics Classes

POS.F-MO.29: Planetarium Use in Introductory Astronomy Courses

Poster – Jason Trump, Brigham Young University

M. Jeannette Lawler, Brigham Young University

Many planetariums are situated at institutions of higher learning but there is little documentation about how these facilities are being used. We present an analysis of a survey designed to explore planetarium use in introductory astronomy courses taught to undergraduates. The survey asked about 11 learning objectives, which were chosen through an investigation of online course descriptions at ten universities. Planetarium users answered questions about what they are teaching, how long they are teaching it, and what media they are using to teach it. We distributed the survey to approximately 289 institutions in the US. There were 85 responses to the survey with 78 providing enough information to be useful. Results show that planetariums are primarily being used to teach the night sky and that planetarium users prefer to teach through unscripted use rather than scripted shows. We discuss potential implications to content development and further research in instructional methodology.

Session: Special Meetups

Tuesday, August 3, 10–11 a.m.

Sponsor: AAPT **Presider:** *David Marasco*

30 Demos in 60 Minutes

Organizer: Wendy Adams, Colorado School of Mines

Sponsoring Committee: Teacher Preparation

Co-sponsoring Committee: High School

Early Career Speed Networking

Professional Skills for Students

This interactive panel focuses on developing professional skills for graduate students and other early-stage researchers. While this session is aimed toward graduate students, we welcome anyone who is interested in this professional development opportunity.

Organizer: Danny Doucette

Sponsoring Committee: Research in Physics Education

Co-sponsoring Committee: Graduate Education in Physics

Partnership Workshop: Curious to learn more about what it takes to become a published author? Want to be in the know with the book publishing partnership with AIP Publishing?

Join us for a panel discussion workshop to learn more about the book publishing process with AAPT and AIP Publishing! You'll hear from AAPT Books Chairperson Laura McCollough and AIP Publishing's Commissioning Editor, Lauren Schultz, about the partnership, and they'll share some inside information about the publishing process. AAPT members and authors Jim Nelson (Teaching about Magnets and Magnetism and Teaching About Geometric Optics) and Rebecca Vieyra (Teaching High School Physics) will share their expertise in writing textbooks and their experiences working with the teams at AIP Publishing.

Come and hear about:

- What fellow members have to say about the triumphs and challenges of the writing process
- How to get started on your book proposal and get some tips from an expert
- Benefits of the book partnership for AAPT members

Diversity, Equity and Inclusion Plenary

$E=MC^2$: Equity-Minded Curriculum and Classrooms

Presider: Alexis Knaub

by Dr. Angela M. White

Assistant Dean of Student Success, Office of Student Success, College of Science and Technology, North Carolina Agricultural & Technical State University

Angela White

Dr. Angela Michelle White has an extreme passion for teaching and learning science. She earned a Bachelor of Science in Biology from the University of North Carolina at Chapel Hill, a Master of Science in Biology from North Carolina Agricultural and Technical State University, and a Doctor of Philosophy in Curriculum and Instruction with a concentration in Educational Psychology from North Carolina State University. Dr. White has served as an educator for 17 years at various levels and currently serves as the Assistant Dean of Student Success for the College of Science and Technology at North Carolina Agricultural and Technical State University. In this role she strategically develops and implements initiatives that promote the participation, academic achievement, and success of students within the College. Her current research interests, publications, and presentations give attention to racial identity, science identity, science self-efficacy, metacognition, and STEM achievement of African American students. As a strong advocate for the participation of African American females in STEM, Dr. White continuously engages in discourse and research that will promote greater access to STEM-related opportunities and recognition of African American females. Dr. White is also the co-founder of NoireSTEM, an educational consulting firm that seeks to increase access and achievement of African Americans in STEM degree programs and careers.

Tuesday, August 3
11 a.m.–12 p.m.

Poster Session II: **Tuesday, August 3, 12:30–2 p.m.**
Sponsor: AAPT

Physics Education Research II Posters

POS.A-TU.01: Using Ensemble Machine Learning to Identify at-Risk Physics Students

Poster – John Hansen, West Virginia University

John Pace, John Stewart, West Virginia University

This study advances the work of previous studies that have applied machine learning algorithms to identify students who are at risk of failure in introductory calculus-based physics. Those prior studies found it very difficult to predict the outcome of students who received a D, an F, or W (withdrawal from the course). This study applies ensemble machine learning—using two or more machine learning algorithms in tandem—to identify students at-risk of failing introductory calculus-based physics. These algorithms are applied using institutional variables such as college GPA and in- class variables such as homework grades. Affective Non-cognitive variables gathered through in-class surveys, such as self-efficacy, are also used to improve identification accuracy.

POS.A-TU.02: Development of an Instrument for Analysis of Student Assistants' PCK-Q*

Poster – Beth Thacker, Texas Tech University

Stephanie Hart, Kyle Wipfli, Jianlan Wang, Texas Tech University

We report on the development of a written assessment designed to analyze pedagogical content knowledge in the context of questioning (PCK-Q). We discuss the process of analyzing and coding classroom videos and writing and testing a written assessment. The classroom observations have first been coded using a coding scheme that analyzes levels of questioning in an inquiry-based classroom. A written instrument was then developed based on the classroom videos, administered to student teaching assistants (TAs and LAs) and compared with the video results to validate the written instrument. We report on the coding scheme and the validation of the instrument as part of this ongoing project.

*Funded by NSF IUSE grant 1838339 Measuring and Improving Pedagogical Content Knowledge of Student Assistants in Introductory Physics Classes

POS.A-TU.03: Looking Beyond the Normalized Gain

Poster – Paul Miller, West Virginia University

John C. Stewart, West Virginia University

In his well-known paper Hake states that "a consistent analysis over diverse student populations with widely varying initial knowledge states […] can be obtained by taking the normalized average gain <g> as a rough measure of the effectiveness of the course in promoting conceptual understanding." The practice of measuring course learning gains is common, despite the fact that variation in <g> on the FCI has also been tied to population effects, such as SAT scores, along which diverse populations are spread [Coletta, 2007]. In our data set of thousands of introductory mechanics students over more than a decade, we see a strong correlation between FMCE gain and math preparation level. We present the lessons we have learned about using normalized gain to study physics instruction, and we suggest how PER researchers might move beyond it to better compare learning in courses that reflect the diversity of the student population.

POS.A-TU.04: Mechanistic Reasoning in the Context of Resource Oriented Instructional Materials

Poster – Clausell Mathis, University of Washington

Lisa Goodhew, Seattle Pacific University

Paula Heron, University of Washington

Russ' (2005) mechanistic reasoning framework which highlights components of reasoning such as identifying entities and activities and chaining these together, was originally developed to analyze student discourse in classroom discussions. The primary objective of this study is to assess the feasibility of the mechanistic reasoning framework for assessing physics students' written work. Samples of students' responses to questions designed to elicit conceptual resources about waves, circuits, heat and temperature, and kinematics were collected from a variety of introductory physics courses. Analysis of these responses presented challenges in applying aspects of the mechanistic reasoning framework, e.g., ambiguity in clarifying students' descriptions of entities and phenomena. This study suggests some possibilities for applying the mechanistic reasoning framework to university physics students' written work.

POS.A-TU.05: Use of Physics Simulations in Supporting Equity and Student Learning

Poster – Emily Allen, The Governor's Academy - Byfield, MA

Andrew Duffy, Manher Jariwala, Vera Degtiareva, Boston University

Sheila Sagear, University of Florida

Computer simulations have been used to support student learning in physics, not only to boost conceptual understanding but to make labs more widely accessible to different populations. However, their impact on student learning has shown mixed results. To better understand this impact, HTML5-based computer simulations for topics in mechanics were investigated in a large, algebra-based, studio physics course for life science students at a private, research-intensive institution. Over a period of three years, we compared learning outcomes of students using traditional hands-on equipment only, a simulation only, or a hybrid combination of both for activities on energy, momentum, simple harmonic motion, and rotational dynamics. We will present our findings of this study through an equity lens, both from the experience of online learning due to the global pandemic and from consideration of the limited access to lab equipment for many students.

POS.A-TU.06: Social-Positioning Correlates with Consensus Building in Two Contentious Large-Group Meetings

Poster – Brant Hinrichs, Drury University

David Brookes, California state university Chico

Jake Nass

This poster analyzes two examples of whiteboard meetings from a college calculus-based introductory physics course taught using University Modeling Instruction. In this pedagogy, students work in small groups to create a solution to the same problem on 2ğ× 3ğwhiteboards. They then sit in a large circle with their whiteboards held facing in and conduct a student-led whole-class discussion ("board" meeting) to reach a consensus. One example is given of a conversation where students overcame sharp disagreements to eventually reach whole-class consensus and another example is given where they did not. We examine how social positioning contributed to students either successfully examining and resolving different ideas or failing to do so. Our analysis suggests that the way students position themselves in discussions may open or close the collaborative space to productive sense-making.

POS.A-TU.07: Student Engagement in the Practice of Developing and Using Models

Poster – Paul Bergeron, Michigan State University

James T. Laverty, Kansas State University

Calls to reform to science teaching have elicited numerous responses over the past decade. One avenue of reform, 3 Dimensional Learning (3DL), focuses on what students learn, instead of how students learn. 3DL achieves this by organizing science learning around the same 3 dimensions that experts organize their knowledge: Scientific Practices, Disciplinary Core Ideas, and Crosscutting Concepts. To aid transformations toward 3DL, the 3DL4US group has created protocols to help characterize when 3DL may occur on assessments and in instruction. In this talk, we present initial results that extend this effort to student engagement with the Scientific Practice of Developing and Using Models. We will look at results from student problem solving interviews to see how the practice manifested in their work. These results will help inform us about the effectiveness of instructional efforts to engage students with the Practice of Using Models as we attempt to create 3DL environments.

POS.A-TU.08: Students' Conceptions and Ideas About "Motion" During Think Aloud Problem Solving Activities.

Poster – Cory Ellis, Cal Poly University - San Luis Obispo

Laura Ríos, Cal Po Cal Poly University - San Luis Obispo

Motion is used in a variety of ways in introductory mechanics contexts. Given the foundational importance of related ideas such as force and acceleration, it might behoove instructors to understand how their students are interpreting this all-encompassing word. In this study, we explored how beliefs and conceptions about motion are refined or used by undergraduate, upper-division physics students in a series of think-aloud interviews with coupled-multiple response (CMR) items developed from free-response data and with two adapted example questions from the Force and Motion Conceptual Evaluation (FMCE).

POS.A-TU.09: Analysis of Computation-based Formative Feedback within the EMP-Cubed Classroom

Poster – Tyler Stump, Michigan State University

Daryl McPadden, Paul W. Irving, Michigan State University - Department of Physics and Astronomy

Recently, there has been a push to incorporate computation into science classrooms. For example, one of the Next Generation Science Standards specifically addresses using mathematics and computational thinking. However, currently, there are few resources to help teachers assess and guide students in these computationally-integrated classrooms. To begin to address this, we present an analysis of the formative feedback given by instructors in a second semester, introductory level physics classroom called Electricity & Magnetism - Projects & Practices in Physics (EMP-Cubed). EMP-Cubed is a flipped, Problem-Based Learning course, which integrates VPython coding projects and minimally working programs. As part of the normal course assessments, instructors provide written formative feedback to groups and individual students. In this analysis, we have pulled the feedback focused on computation and identified themes in topic, purpose, & recipients. We discuss the implications of these results for instructors adding computation to their courses.

POS.A-TU.10: Using Deliberate Innovation to Understand Indifference in Graduate Advisor/Advisee Relationships

Poster – Erika Cowan, Georgia Institute of Technology

Garrett Price, Georgia Institute of Technology

Michael Schatz, Georgia Institute of Technology

Advisors and graduate students are sometimes stuck and not moving their research forward. We use Deliberate Innovation(DI) techniques to understand the specific situations centered around research that graduate students and their advisors find themselves in that may be problematic. A critical element of this is determining whether advisors and advisees show indifference in particular situations. We understand indifference by noticing what people are and are not drawn to in the research setting, and will be focusing on ways in which we have seen it show up. Finding this indifference allows us to know where to focus our attention, with the ultimate goal of finding situations in which we can help graduate students and advisors get unstuck and move their research forward.

POS.A-TU.11: Comparing NSF Funding Programs for Physics and Engineering Education

Poster – Rebecca Rosenblatt, AAAS-STPF

A text-based analysis was completed to identify the funding programs from the National Science Foundation (NSF) that have supported the physics education and engineering education communities. Specifically, the Physics Education Research Conference proceedings and the Frontiers in Education proceedings between 2010-2019 were analyzed to identify the seven-digit award numbers acknowledged on these publications. NSF's public award database https://www.nsf.gov/awardsearch/ was then used to pull information about which program provided this funding and, via the award abstract, some information about each project. Open coding was then completed to identify trends. This presentation will compare the different programs which fund these disciplines, the stated goals of each funding program, and patterns seen in award abstracts. The goal of this analysis is to inform the physics education community about the kinds of work being completed and funded from these two adjacent education communities, who often overlap in terms of research interests and members.

POS.A-TU.12: Students' Self-Efficacy in an Accelerated Remote Introductory Lab Sequence

Poster – Paul DeStefano, Portland State University

Cass Croft, Ralf Widenhorn, Portland State University

In summer 2020, an accelerated, 9-week version of the full-year introductory physics laboratory sequence was offered in the emergency remote teaching (ERT) environment. The three term sequence covers mechanics in the first course, electromagnetism in the second, and finally wave, optics and thermodynamics in the last course. Students had to complete three labs each week. We discuss the process for transitioning the traditional laboratory curriculum of the courses to ERT. We also describe changes to the third course in the sequence that were informed by preliminary results from a study of students' attitudes conducted during the rapid remote implementation of the spring 2020 instance of the course. Finally, we show changes in students' attitudes over the three course sequence.

POS.A-TU.13: Examining the Dynamics of Decision Making When Designing Curriculum in Student Partnerships

Poster – Erin Sohr, University of Maryland College Park

Ayush Gupta, Mithibai College

Brandon J Johnson, University of Maryland College Park

Gina M Quan, San Jose State University

Common models of curricular development often involve hierarchical relationships between researchers and students, where researchers lead the design and testing of curriculum for students. Several years ago, informed by work in Students as Partners, we began to undertake curriculum design in partnership with students. We invited undergraduate physics students to participate in a team tasked with codesigning quantum mechanics tutorials. In this presentation, we will summarize an analysis of one interaction in which researchers attempted to create space for students to contribute to decision making around the codesign process. Through analyzing interactional dynamics, we describe how access to decision-making was opened up and/or cut off to students and how the interactional dynamics often contested or reaffirmed participants' roles. We aim to self-critically reflect on the challenges and tensions that emerge in facilitating codesign partnerships. We discuss our own areas for growth and speak to implications for more responsible partnerships.

POS.A-TU.14: Problem Solving as a Process of Translating Between Semiotic Modes

Poster – John Thomas, University of Georgia

Nandana Weliweriya, Universtiy of Georgia

Representations refers to sketches, diagrams, pictures, graphs, tables, and mathematical equations are representations we commonly use in undergraduate physics courses and STEM more broadly. We use a social semiotic perspective to sketch a theoretical framework that accounts for how students use semiotic resources, such as physical or verbal representations, to understand better and solve physics solving problems. This study focuses on the problem-solving videos with narration (Pencasts) generated by the students enrolled in the calculus-basted Physics courses in the fall 2020 semester. Based off the Pencasts it is clear to see that students can understand and organize problems more efficiently as they translate between semiotic modes. Students use the representations they have constructed to find meaning, in doing so build upon representations or create new ones. This leads students to translate through different semiotic modes such as: visual, verbal, and gestural that drive their ability to solve the problem.

POS.A-TU.15: The Effect of Dual Process Theory Instruction on Student Learning*

Poster – Alistair McInerny, North Dakota State University

Mila Kryjevskaia, North Dakota State University

Andrew Boudreaux, Western Washington University

Reasoning across different contexts consistently is a challenge when learning physics. Despite demonstrating correct conceptual understanding and reasoning on one task, students often fail to use the same knowledge and skills on similar tasks. Dual-process theories can explain these inconsistencies, asserting that cognition involves two thinking processes: the heuristic, which is fast and automatic, and the analytic, which is slow and deliberate. Inconsistent responses arise when the heuristic process produces an intuitively appealing (but incorrect) response that the analytic process fails to reject. We hypothesize making the dual nature of human cognition explicit and more visible to the students could help them recognize and evaluate intuitive responses more productively. Results of a study designed to probe the impact of such instruction on student learning in introductory calculus-based mechanics courses are presented here.

*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

POS.A-TU.16: Measuring Students' Level of Understanding in Introductory Physics Courses

Poster – David Waters, University of Health Sciences and Pharmacy in St. Louis

Brooke Anthonies, University of Health Sciences and Pharmacy in St. Louis

An instructor may often wonder what their students understand from their lessons or may want to know what students already understand before coming to class. While formative assessments can help, they can also be stressful and time consuming. During the fall and spring semesters from 2018 to 2021 in Physics I and Physics II, students reported their level of understanding of the material before and after each class. This information helped to inform the instructor on how to teach the class as well as how well the class went and what material might need to be reviewed. We graphed the average level of understanding for each class session to compare the students' understanding before and after class, between semesters, and between years. Each semester is analyzed for trends, and we plan to share the interesting results that were found.

POS.A-TU.17: Personas of Student Completing Online Instructions During the COVID-19 Pandemic

Poster – Cora Romick, The University of Georgia

Emma Zipperer, Tara Cotton, Nandana Weliweriya, University of Georgia

Among the many significant challenges raised by the Covid-19 pandemic, many educators had to face the most significant challenge to convert well-designed in-person instruction methods to online teaching methods. To improve educators' online teaching methods to increase comprehension in classrooms, we collected data from STEM introductory level courses in the form of student feedback surveys, and personal interviews conducted online. We used persona methodology and ethnography to document the diverse learning group in a STEM classroom. Personas are "life-like models, whose characteristics are driven by the various goals and motivations of real or potential users." We used these personas to learn how an individual's learning experience affects their participation, goals, motivations, and expectations during online learning. These personas can support the design of online courses with student- centered approaches that better engage undergraduate students across multiple disciplines.

Cora Romick is the first author of this poster mentored by Nandana Weliweriya. Since Cora is not a current AAPT member Nandana Weliweriya is submitting this abstract.

POS.A-TU.18: Student Feedback: Transition to Online Instructions During the COVID-19 Pandemic

Poster – Emma Zipperer, University of Georgia, Athens

Tara Cotten, Maduranga Dassanayake, Nandana Weliweriya, University of Georgia

During the mid-part of the spring 2021 semester, the COVID-19 pandemic forced the conversion of well-designed in-person instruction methods to online teaching methods. During the Fall 2020 semester, Introductory Physics students at the University of Georgia were asked about their experiences with their online instructions during the COVID-19 pandemic, with an idea to use this feedback to improve further instruction in the following semesters. We gathered our research by collecting student feedback surveys from students in SCALE-UP classrooms where group-based learning is prevalent. The survey included multiple choice and open response questions about camera and privacy, preferred methods of group activities, and their tendency to participate. Data was collected across multiple STEM disciplines. Students found the instruction to be presented more clearly when attending in-person, and many requested the use of more real-life examples during class time.

Emma Zipperer is the first author of this poster mentored by Nandana Weliweriya. Since Emma Zipperer is not a current AAPT member Nandana Weliweriya is submitting this abstract.

POS.A-TU.19: Students' Problem-Solving Processes Associated with Representations in Pencasts.

Poster – Katie Tran, University of Georgia

Nandana Weliweriya, University of Georgia

The term 'Representations' refers to sketches, diagrams, pictures, graphs, tables, and mathematical equations are representations we commonly use in undergraduate physics courses and STEM more broadly. Even though expert instructors are familiar with these representations, the studies show that novice students are often struggling to understand and use these representations. Studies on the use of social semiotics in physics classrooms suggest that the instructors explain representations at a basic level and then, more in-depth, all physics representations. We collect student-generated problem-solving videos (Pencasts) from calculus- based physics courses at UGA. In this study, we analyze we look for patterns of students internalizing and combining representations to solve physics problems. In this poster, we present our initial findings. We find that students commonly use tables and visual representations with individualization to maximize learned skills and incorporate their understanding in the class. We expect to extend our work to other STEM branches.

Katie Tran is the first author of this poster mentored by Nandana Weliweriya. Since Katie Tran is not a current AAPT member Nandana Weliweriya is submitting this abstract.

POS.A-TU.20: Social Semiotic Resources to Investigate STEM Problem Solving with Representations

Poster – Maria Adams, University of Georgia

Nandana Weliweriya, University of Georgia

Introductory-level Physics courses are often taken by students who plan to study science, engineering, or mathematics in the future and those who want to get involved in a field that utilizes physics principles and models. However, the combinations of mathematics and diagrams used to solve most physics problems prevent students from understanding the material. This issue brings us to the need to investigate how students understand and use representations while solving undergraduate-level physics problems. In this study, we use student-generated problem-solving videos (Pencasts). Our analysis uses a social semiotic perspective to sketch a theoretical framework that accounts for how students use semiotic resources to build representations to solve problems. This work will help us better understand when solving a problem how and where students are more likely to get stuck, like in mathematics or the diagram's drawing. We expect to extend our work and generalize our findings across STEM disciplines. Maria Elizabeth Adams is the first author of this poster mentored by Nandana Weliweriya. Since Maria Elizabeth Adams is not a current AAPT member Nandana Weliweriya is submitting this abstract.

POS.A-TU.21: The Impact of Online College Science Courses on Student Anxiety

Poster – Tasneem Mohammed, Arizona State University

Katelyn Cooper, Arizona State University

Anxiety is the top mental health concern among undergraduates and thought to be particularly high among science students. However, there is little known about how online science courses affect anxiety. In this study, we surveyed over 2100 undergraduates about their anxiety in large-enrollment online science courses. We used open-coding and logistic regression to analyze the data. Students reported that technology issues (69.8%), proctored exams (68.0%), and difficulty getting to know peers (67.2%) increased their anxiety online. Accessing content at a later time (79.0%), attending class from where students want (74.4%), and not having to be on camera (73.5%) decreased their anxiety. Students suggested that instructors could decrease anxiety in online courses by increasing test-taking flexibility (25.0%) and having an organized course (14.7%). This study provides insight into how instructors can create more inclusive online learning environments for students with anxiety.

POS.A-TU.23: AGEP Alliance Model for Underrepresented STEM Doctoral Candidates at HBCUs

Poster – Willie Rockward, Morgan State University

Jana R Talley, Jackson State University

Grace M Ndip, Virginia State University

Brenda R Brand, Virginia Polytechnic Institute and State University

Jeremy Ernst, Embry-Riddle Aeronautical University

This AGEP Alliance model provides faculty professional development and career preparation to minority STEM doctoral candidates. To increase the numbers of historically underrepresented faculty in STEM, the target audience is instructors at Historically Black Colleges and Universities (HBCUs) that are in the dissertation stage of their PhD degree. The Alliance's HBCU Instructors Bridge to Academia Program (HI Bridge) consists of research seminars, research advising, faculty mentoring, research presentations, peer collaboration, networking, and alumni follow-up meetings. These activities are designed to support the candidates in completing their PhDs and also prepare them for success in their faculty careers. Our work is also designed to identify factors that influence attrition rates of the target audience. We will be presenting the organizational structure of the Alliance team and the progress that has been made with the first cohort of participants.

POS.A-TU.24: Optimum Separation of Two Plates for Maximum Potential Difference

Poster – Binoy Das, J K College

Nityananda Das, J K College

The parallel plate capacitors are used in many applications. The calculation of voltage of the two triboelectric plates is very important to calculate the maximum potential difference that can be obtained in triboelectric nano generators. Due to the fringing of electric field lines the potential difference between the two plates varies in a nonlinear manner with separation distance and plate size. The nature of the field variation and hence the average potential difference as a function of plate size is simulated and the separation for maximum potential difference is calculated. To have a better insight, the energy calculation is also performed. This enables us to calculate the voltage generated by nano generators and hence the maximum obtainable power.

Pre-college/Informal and Outreach Posters   Tuesday, August 3, 12:30–2 p.m.

POS.B-TU.01: Teaching Physics Using Agricultural Concepts

Poster – Diedre Young, University of Arkansas System Division of Agriculture Cooperative Extension Service

Daniel E Young, University of North Carolina-Chapel Hill

In Arkansas we are primarily an agricultural economy with billions of dollars accrued through crop production. Because of this, agriculture should be represented in Arkansas classrooms and in national education as agronomy requires a broad range of STEM trained graduates. Teachers can introduce basic physics concepts such as fluid flow and thermodynamics using real world agricultural scenarios and in-class demonstrations such as measuring water amount in soil to demonstrating the effect of water evaporation in irrigation systems (and the resultant cost of such). As a cross cutting concept, soybeans are cultivated to be used in the implementation of this lesson to determine water evaporation which includes discussion of soybean transpiration. The concepts and examples presented can easily be modified for any science classroom using local crops.

POS.B-TU.02: Development of Historical Vignettes in Teaching Physical Science in SHS

Poster – Voltaire Mistades, De La Salle University

Sherwin D Movilla, Hyacinth Mae D Capino, Joy Q Batang, De La Salle University

We report the design and development process undertaken by the authors in putting together historical vignettes that could be used as supplementary materials in teaching Physical Science in Senior High School. The use of historical physics vignettes humanizes science to the students and allows them to develop an understanding of the nature of science. In this paper, we present three examples of the historical vignettes that had been developed: (1) an interactive historical vignette about Galileo and his astronomical discoveries; (2) a vignette presented in role-play format that highlights the contributions of Oersted, Ampere, Faraday, and Maxwell; and (3) a comics-format vignette contextualized in the Philippines setting, featuring the story of the first female National Scientist of the Philippines. The vignettes featured guide questions that encourage the students to think about their views about the nature of science.

POS.B-TU.03: Grad Students Unite! Collaborations in Virtual Public Engagement

Poster – Bryan Stanley, Michigan State University

The COVID-19 pandemic has forced many informal physics programs to adapt, evolve, and create new ways to continue their public engagement efforts. Women and Minorities in the Physical Sciences (WaMPS) is a graduate student organization housed in the department of physics and astronomy at Michigan State University. WaMPS is a student-led organization encouraging women and minorities to pursue the physical sciences and supporting those who are already members of the physical science community. Most of the pre-COVID WaMPS outreach and public engagement consisted of in-person events, including school visits and public presentations with hands-on demonstrations. The COVID-19 pandemic put a halt on those types of activities. In this poster, we discuss how social media and podcasting increased our collaborations with other university departments. These new partnerships allowed us to create more engaging interdisciplinary public engagement activities and expand our community of graduate student volunteers.

POS.B-TU.04: Gender Gap in Physics: An Important Initiation from Cameron University

Poster – Susmita Hazra, Cameron University

Ann Nalley, Cameron University

Studies have shown that one of the best ways to include more number of girls in Physics is to influence them from an early age in their middle school. Department of Chemistry, Physics & Engineering of Cameron University has been hosting a one week long summer residential academy for 12 middle school girls. This Academy is named as “Aerospace Engineering and Applied Physics for Middle School Girls”. Two female professors from the department serve as directors in this summer program. Through this academy, we encourage the girls by including them in lot of hands-on activities related to applied physics and Engineering. They learn principles of aerospace, mechanics and rocket design by utilizing equipment in a very active learning environment set-up. We believe our program has been very helpful to many girls and in future we look forward to extend this program to include more girls and other areas of STEM.

POS.B-TU.05: A Virtual Physics Camp for Middle School Girls during COVID

Poster – Roberto Ramos, University of the Sciences

How does one run a virtual physics camp for middle school girls during the COVID pandemic ? I will present my experience in organizing and executing the Virtual Physics Wonder Girls Summer Camp in 2021. The theme of this year's free, week-long physics camp revolves around renewable energies and quantum physics. On its ninth year, the camp provides immersion experiences to cohorts of middle school girls selected from a pool of high-performing students in the Philadelphia-New Jersey area. Campers come from diverse communities and are introduced to renewable energy and the basics of solar cells, and experience project-building by building and testing solar cars, and solar boats, and do hands-on optics experiments. Campers receives a free kit of materials for projects and experiments. Campers interact with physics majors who serve as crew, women physicists and engineers, experience virtual tours of plants and manufacturing facilities, and give capstone presentations. Website: https://sites.google.com/usciences.edu/physicswondergirlscamp/

Teacher Training/Enhancement Posters — Tuesday, August 3, 12:30–2 p.m.

POS.D-TU.01: Exploring Physical Phenomena: A Physics Course for Prospective Teachers

Poster – Emily van Zee, Oregon State University

Kelby Hahn, Olivia Adams, Elizabeth Gire, Oregon State University

Our open-source textbook, Exploring Physical Phenomena: What Happens When Light from the Sun Shines on the Earth? is now available at https://open.oregonstate.education/physicsforteachers. Each unit begins by identifying student resources for learning, developing central ideas based on evidence from exploring phenomena with everyday equipment and materials, using central ideas to explain intriguing phenomena, developing mathematical representations of the phenomena, using those representations to predict or estimate a quantity of interest, and making connections to educational policies such as the Next Generation Science Standards. All units include examples of student work by prospective elementary and middle school teachers while exploring light and thermal phenomena, considering the influence of light and thermal phenomena on local weather and global climate change, and exploring astronomical phenomena in the context of the Sun/Earth/Moon system. Supplemental materials include instructor guide for each unit, equipment lists for both on-campus and remote instruction, student handouts, and example homework assignments.

POS.D-TU.02: Affordances of a Noyce Program -STEM Center partnership

Poster – Steve Robinson, Tennessee Technological University

Holly Anthony, Tennessee Technological University

The Tennessee Technological University - STEM Majors for Rural Teaching (TTU-SMaRT) Noyce program has partnered closely with TTU’s MIllard Oakley STEM Center. In this poster we describe how this mutually beneficial partnership has provided a low-stakes environment in which Noyce students gain authentic instructional experiences, exposure to pedagogical innovations, meaningful interaction with practicing teachers, and early integrations with the local STEM teaching community. This partnership has also enabled the STEM Center to offer more outreach opportunities than it otherwise could. Lessons developed by scholars have contributed to a 'library' of standards-based activities that have also broadened the scope of what can be offered.

Teaching the Introductory Physics for the Life Sciences (IPLS) Course Posters — Tuesday, August 3, 12:30–2 p.m.

POS.E-TU.01: Modeling Bite Pressure Using Popcorn Kernels, a Lever, and iOLab

Poster – James Vesenka, University of New England

Laurel Wildfong, University of New England

In this poster we model the "bite force" and associated pressure required to crush a popcorn kernel using a simple lever system and measuring the load with an iOLab force sensor as part of a pandemic lab practicum exploration. By estimating the area of the lever in contact with the popcorn kernel we experimentally determined an average pressure required to crush the kernel consistent with internal pressures measured to explode an average popcorn kernel, reported to be around 135 psi. For some people the force associated with this pressure is sufficient to crack an apparently healthy tooth. This activity achieved the following lab practicum objectives.

- Inexpensive activity created from easily accessible items at home.
- Applied life science activity, in this case related to dentistry.
- Employed an inexpensive physics-in-a-box force sensor, the iOLab.

POS.E-TU.02: Development of Dynamics Questions for the Fluids Conceptual Evaluation (FCE)

Poster – Dawn Meredith, University of New Hampshire

Ian Coburn, Jason Jung, James Vesenka, Daniel Young, University of North Carolina at 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 process of how we selected the fluid dynamics constructs and the process of writing and refining the dynamics-related questions. Instructors interested in serving as a field test site should contact Project Lead Dawn Meredith.

POS.E-TU.03: Implementation of a Biomedically Relevant Active-Learning Physics Curriculum*

Poster – Mayuri Gilhooly, Rockhurst University

Nancy Donaldson, Rockhurst University

This poster will address development and initial implementation of a NSF grant funded biomedically relevant active-learning curriculum in my second semester Physics for the Life Sciences course. This NSF grant funded curriculum provides students with a biomedically relevant curriculum that stresses the importance of physics as a basic science relevant to their future medical/healthcare careers. I will provide insight as to how I contributed in the development process and adapted curricular materials of Rotational Kinematics and Torque in a flipped classroom setting and how this benefited me in my pedagogical growth in teaching physics. Further, pre-post analysis of attitude survey results will be addressed to show the effectiveness of the curriculum.

*This work is supported by the grants DUE- 1934038 and DUE- 1933984 from the National Science Foundation.

POS.E-TU.04: Implementation of a Full Year Introductory Physics Sequence Pre-Health Students*

Poster – Priya Jamkhedkar, Portland State University

Ralf Widenhorn, Portland State University

In this poster we summarize the implementation of a full year introductory physics sequence for life science and pre-health students at Portland State University. Curricular materials such as videos by experts in the medical field, content, activities, simulations and assessments around medical examples and applications were developed. These were delivered through an adaptive, personalized, and interactive online platform Cogbooks. In this poster, we present the development, implementation, and early results from student surveys. We conclude the poster with lessons learned and future improvements based on student feedback.

*This work is supported by the grants DUE- 1624192 and DUE- 1933984 from the National Science Foundation.

POS.E-TU.05: The Absorption Spectrum of Organic Molecules

Poster – David Waters, University of Health Sciences and Pharmacy in St. Louis

Juan Rodriguez, University of Health Sciences and Pharmacy in St. Louis

Students use the lab portion of an algebra-based introductory physics for the life sciences course to measure the absorption and emission spectrum of organic molecules. They prepare samples containing the organic molecules crocetin (saffron), acetylsalicylic acid (apirin), lycopene (tomato paste), and chlorophyll. Once students obtain the absorption spectrums, they're able to use their knowledge of color absorption to see why organic materials absorb and reflect certain colors. The exciting finding is when they see that chlorophyll absorbs in the blue and red. This means that if blue light shines onto a sample made with the extract from a leaf, the chlorophyll makes the solution glow red.

POS.E-TU.06: Health/life Scenario Digital Worksheets with Student Choice of Details

Poster – Nancy Beverly, Mercy College

Digital worksheet questions based on health and life scenarios were developed for students in an introductory physics for life science course, to practice conceptual and algebraic modeling and quantitative analysis. Many of the quantitative values used were students' own estimations or data or choice of scenario parameters from authentic data tables and graphs provided. Students would get different numerical answers depending on their details of choice, and possibly different evaluations of what their numerical answer inferred about the scenario. These materials were meant to support student transition into exploring the physics mechanisms underlying their own health/life scenarios.

POS.E-TU.07: Development of Statics Questions for the Fluids Conceptual Evaluation (FCE)

Poster – DJ Wagner, Grove City College

Caleb Barber, Grove City College

Jason Jung, University of New Hampshire

Rebecca Lindell, Tiliadal STEM Education: Solutions for Higher Education

Dan Young, University of North Carolina at 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 process of how we selected the fluid statics constructs and the process of writing and refining the statics-related questions. Instructors interested in serving as a field test site should contact Project Lead Dawn Meredith (dawn.meredith@unh.edu).

Technologies Posters — Tuesday, August 3, 12:30–2 p.m

POS.F-TU.01: An Analogy-based 3D-Simulation for Teaching Simple Electric Circuits

Poster – Jan-Philipp Burde, University of Tübingen

Thomas Sean Weatherby, University of Frankfurt

Arthur Kronenberger, University of Salzburg

Understanding the basic concepts of electricity represents a major challenge to most students in K-12 education. Learners find it particularly difficult to develop a robust understanding of potential and potential difference and often believe that the electric current is "used up" by devices. A promising way of making circuits more accessible to students in introductory electricity lessons is offered by the use of analogies in combination with simulations. We therefore developed a new, analogy-based simulation of simple electric circuits. The simulation is intended for use in combination with the bike chain and the air pressure analogies, the implementation of which has been shown to support students' development of a conceptual understanding of simple DC circuits. Teachers and students can access the 3D simulation free of charge using a modern browser.

POS.F-TU.02: Beyond Email: Effective Communication Strategies to Engage Students of Physics

Poster – Kristin Poduska, Memorial University of Newfoundland*

Building a positive and inclusive cohort feel among students of physics is challenging when their first postsecondary experience is in large lecture-style courses. To this end, this poster will describe the range of different communication technologies and tools that my Department has used to increase our formal and informal communication with undergraduate students of physics at different stages of their degree programs. Comparisons focus on three aspects: the instructor/administrator's intended goal for usage, the actual usage patterns by students during (pre-COVID) in-person learning, and the actual usage patterns by students during (COVID-necessitated) remote learning.

*Sponsor: Dr. Sarah Johnson (Simon Fraser University, BC, Canada)

POS.F-TU.03: Energy in Magnetic Fields: A Hands-on Activity and Preliminary Assessment

Poster – Rebecca Vieyra, University of Maryland-College Park

Ramon Lopez, University of Texas at Arlington

While students and teachers often consider how energy can be stored in gravitational fields, other force fields (such as magnetic fields) receive much less attention. Using solar flare reconnection as a real-world context, we presents an activity using an AR-based magnetic field display tool (Magna-AR) to help students consider the relationship between fields and the energy in magnets. We also present a draft conceptual assessment to measure students' understandings of energy in magnetic fields.

Upper Division and Graduate Posters **Tuesday, August 3, 12:30–2 p.m**

POS.G-TU.01: Online Tutorials for Middle-Division Quantum with Adaptive Guidance

Poster – Giaco Corsiglia, University of Colorado, Boulder

Benjamin P Schermerhorn, Gina Passante, California State University, Fullerton

Homeyra Sadaghiani, California Polytechnic University Pomona

Steven Pollock, University of Colorado, Boulder

Research-based tutorials---worksheets that guide students in constructing physics knowledge for themselves---have repeatedly proven to be a highly effective complement to lectures in physics courses. Our collaboration has created a collection of tutorials for middle-division quantum mechanics (QM), which has been successfully adopted by QM instructors nationwide. However, many instructors lack the resources and/or institutional support to run tutorials; it can be difficult to find time, space, and personnel to facilitate these activities. As an alternative, we are developing online versions of our QM tutorials that students can work through without instructor facilitation. We are designing the online tutorials to guide students through the worksheets in ways that encourage sense-making and allow students to progress without revealing the answers. For example, they include adaptive guidance pathways based on students' responses. Early beta versions are available, for free, at acephysics.net.

POS.G-TU.02: Improving the Communication Skills of STEM Graduate Students

Poster – Shannon Willoughby, Montana State University

Kent Davis, Brock La Meres, Leila Sterman, Montana State University

Jenny Green, Michigan State University

We report on a three-year grant aimed at improving the oral communication skills of STEM graduate students. By teaching storytelling techniques, playing improvisation games and recording podcasts, eight STEM storytellers per cohort took a year-long class to develop their skills as speakers. Funded by the NSF Innovations in Graduate Education program, (#1735124) we used formative and summative assessments for determining students' levels of anxiety before giving talks, apprehension for public speaking, and we calculated how much jargon each student employed while discussing their thesis work for a general audience. We collected data on all three cohorts, with 22 of the 24 completing a full year of coursework related to communication skills. Quantitative and qualitative results will be shared in this poster, demonstrating that the publicly available STEM Storytellers curriculum is a powerful method for improving the oral communication skills of STEM graduate students.

POS.G-TU.03: Student Difficulties with Diagonal Operators for Degenerate Perturbation Theory

Poster – Christof Keebaugh, Franklin & Marshall College

Emily Marshman, Community College of Allegheny County

Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with the representation in which a Hermitian operator cor- responding to a physical observable (e.g., the Hamiltonian operator corresponding to energy) is diagonal in the context of degenerate perturbation theory involving the Zeeman effect in the hydrogen atom. This investigation was carried out in advanced quantum mechanics courses by administering written free-response and multiple- choice questions and conducting individual interviews with students. We discuss the common student difficulties related to these concepts, knowledge of which can be useful for developing research-validated learning tools.

POS.G-TU.04: Comparing Undergraduate and Graduate Student Reasoning on Conceptual Entropy Questionnaire

Poster – Nathan Crossette, University of Colorado Boulder

Michael Vignal, Bethany R Wilcox, University of Colorado Boulder

In a prior study, we investigated graduate student reasoning around a set of entropy-related conceptual tasks in a think-aloud format. The tasks involved entropy from microscopic and macroscopic perspectives, ideal gases, and a novel context involving a system with a dynamic string. We conducted interviews with undergraduates using the same questionnaire. Most students were interviewed during the second half of their upper-division Thermal Physics course at the University of Colorado Boulder, while two were upper-division undergraduates from other institutions with strong physics programs. We will explore the similarities and differences between the undergraduate and graduate students' responses in the interviews. In particular, we will compare the conceptual resources used by the two groups of students. The similarity of two of our interview tasks with questions used by other researchers in previous studies of student reasoning with entropy will also allow us to make direct connections with prior research.

POS.G-TU.05: A Knowledge-in-Use Assessment for Upper-Division Thermal Physics

Poster – Katherine Rainey, University of Colorado Boulder

Amali Priyanka Jambuge, Amogh Sirnoorkar, James T Laverty, Kansas State University

Additional Author | Bethany R Wilcox, University of Colorado Boulder

Research-based assessments can provide instructors insights into the efficacy of their teaching and course transformations. As education shifts to focusing more on scientific practices and crosscutting concepts in addition to conceptual knowledge, there is a need for an assessment that can assess these 3-dimensions of learning and inform instructional approaches that foster this learning. In this poster, we present a first-look at an upper-division thermal physics assessment that explicitly targets scientific practices, crosscutting concepts, and conceptual knowledge using coupled, multiple-response items. We will present an example assessment item and discuss ways in which instructors can help with the development process of this assessment while incorporating it into their classrooms. Faculty administering the assessment would receive detailed feedback about their class's overall performance with recommendations for how to adjust instruction to improve student outcomes.

APS Plenary: Quantum Computing

Tuesday, August 3
2:15–3:15 p.m.

Ray-based Framework for Tuning Quantum Dot Devices: Two Dots and Beyond

by Justyn Zwolak

Arrays of quantum dots (QDs) are one of the many candidate systems to realize qubits—the fundamental building blocks of quantum computers—and provide a platform for quantum computing [1]. However, the current practice of manually tuning QDs is a relatively time-consuming procedure, inherently impractical for scaling up and other applications. Recently, we have proposed an auto-tuning paradigm that combines a machine learning (ML) algorithm with optimization routines to assist experimental efforts in tuning semiconductor QD devices [2,3]. Our approach provides a paradigm for fully-automated experimental initialization through a closed-loop system that does not rely on human intuition and experience.

To address the issue of tuning arrays in higher dimensions, we expand upon our prior work and propose a novel approach in which we "fingerprint" the state space instead of working with full-sized 2D scans of the gate voltage space. Using 1D traces ("rays") measured ("shone") in multiple directions, we train an ML algorithm to recognize the relative position of the features characterizing each state (i.e., to "fingerprint") in order to differentiate between various state configurations. I will report the performance of the ray-based learning when used off-line on experimental scans of a double dot device and compare it with our existing, CNN-based approach [4]. I will also discuss how it extends to higher-dimensional systems. Using rays not only allows us to automate the recognition of states but also to significantly reduce (e.g., by 70 % for the two-dots case) the number of measured points required for tuning.

[1] D. Loss and D. P. DiVincenzo. Phys. Rev. A, 57: 120âǦ‘126, 1998.
[2] S. S. Kalantre, J. P. Zwolak, S. Ragole, X. Wu, N. M. Zimmerman, M. D. Stewart, Jr., J. M. Taylor. Machine learning techniques for state recognition and auto-tuning in quantum dots. npj Quantum Inf. 5 (6): 1âǦ‘10 (2019).
[3] J. P. Zwolak, T. McJunkin, S. S. Kalantre, J. P. Dodson, E. R. MacQuarrie, D. E. Savage, M. G. Lagally, S. N. Coppersmith, M. A. Eriksson, J. M. Taylor. Autotuning of Double-Dot Devices In Situ with Machine Learning. Phys. Rev. Applied 13, 034075 (2020).
[4] J. P. Zwolak, T. McJunkin, S. S. Kalantre, S. F. Neyens, E. R. MacQuarrie, M. A. Eriksson, and J. M. Taylor. Ray-Based Framework for State Identification in Quantum Dot Devices. PRX Quantum 2, 020335 (2021).

Crystal Point Defects for Quantum Information Applications: From Deep Centers in Diamond to Shallow Impurities in Semiconductors

by Kai-Mei C. Fu

Point defects in crystals are the solid state analog to trapped ions. Thus these “quantum defects” have gained popularity as qubit candidates for scalable quantum networks. In this talk, I will introduce some of the basic quantum defect properties desirable for quantum network applications and give some illustrative examples of recent successes toward scalable quantum networks, highlighting my group’s work on single NV centers in diamond and shallow donors in ZnO. I will also discuss outstanding challenges (or opportunities) toward scaling quantum systems based on defects.

Kai-Mei is an Associate Professor of Physics and Electrical and Computer Engineering at the University of Washington. She is the Director of the UW NSF Research Traineeship program Accelerating Quantum-Enabled Systems. Her research focuses on understanding and engineering the quantum properties of point defects in crystals, and utilizing these properties in photonic devices for quantum information and sensing applications. Kai-Mei Fu received her A.B. in Physics from Princeton University in 2000 and Ph.D. in Applied Physics from Stanford University in 2007.

Picture of a Scientist Discussion

Tuesday, August 3
3:15–3:45 p.m.

PICTURE A SCIENTIST chronicles the groundswell of researchers who are writing a new chapter for women scientists. Biologist Nancy Hopkins, chemist Raychelle Burks, and geologist Jane Willenbring lead viewers on a journey deep into their own experiences in the sciences, ranging from brutal harassment to years of subtle slights. Along the way, from cramped laboratories to spectacular field stations, we encounter scientific luminaries – including social scientists, neuroscientists, and psychologists – who provide new perspectives on how to make science itself more diverse, equitable, and open to all.

K-12 Teachers Meet-up

Wednesday, August 3, 10–11 a.m.

Meet-up for Members and Supporters of the LGBTQ Community

Wednesday, August 3, 10–11 a.m.

Early Career Topical Discussion

Wednesday, August 3, 10–11 a.m. Sponsor: Committee on Research in Physics Education 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

Applying Cognitive Science to Physics Education: The Legacy of Frederick Reif, a Pessimist who Loved Optimists

Wednesday, August 3, 10–11 a.m. Sponsor: Committee on Research in Physics Education Presider: *Leon Hsu*

SPEC01: The Legacy of Frederick Reif, a Pessimist who Loved Optimists

Invited – Leon Hsu

The goal of this session is to pay tribute to the work of Fred Reif and to contribute to the intellectual continuity of Physics Education Research by raising awareness of his work and how it lives on in current research. Three speakers who have worked closely with Fred will pre-record short talks about his contribution to their work. The live virtual session will begin with a short recap of the talks. Three discussants will add commentary on Reif's legacy and highlight the central influence of Fred Reif on current work in Physics Education Research. There will also be a discussion with the audience, speakers, and discussants.

SPEC02: Learning to Take Education Seriously, and Conduct Research Accordingly

Invited – Alan Schoenfeld

Fred Reif chaired the SESAME group at Berkeley in the 1970s. He hired me as a postdoc, overseeing my transition from a young mathematician engaged in the business of proving theorems to a fledgling educational researcher and cognitive scientist. Fred made it clear that a major challenge with regard to education is that everybody has an opinion, but such opinions were typically grounded and not subjected to rigorous analysis or study. My first semester I sat in on an instructional design course he taught, in which we took the entire term to design one hour of instruction – building a theory of what it meant to understand the idea, designing materials on the basis of a theory of intervention, building an assessment of understanding, and then using it to test both the ideas and the intervention.

SPEC03: Fred Reif's Principled Approach… to Everything!

Invited – Lisa Holt

As Fred's last official doctoral student, I will discuss his influence on my work and his legacy for me. His impact on physics education research stems from his focus on the student rather than the science content itself. His problem-solving approach always started with first principles, and he treated teaching the same way – the first principle was to focus on the learner. By carefully enumerating the thought processes needed to solve problems and the barriers students face in acquiring these skills, he was able to design instructional interventions to help students transform their knowledge from fragile and superficial to robust and flexible. Although I have gone on to work in a variety of domains, I remain faithful to Fred's principles by always focusing on the human.

Optimist Lever to Promote Knowledge Integration in the Physics Classroom

Invited – Bat-Sheva Eylon

Working with Fred on a PhD, and continuing to benefit from his mentorship for many years, was an unprecedented privilege and a model how to work collaboratively with students, peers and teachers. We, the PER group at the Weizmann Institute, continued to benefit from his generous and insightful mentoring.

Changing Graduate Admissions: A Topical Discussion

Wednesday, August 3, 10–11 a.m. Sponsor: AAPT Presider: *Geoff Potvin, Florida International University*

The pandemic has prompted a shift in graduate admissions practices. In addition, an increasing number of departments have been dropping GRE scores as a requirement or criterion for admission and experimenting with holistic admissions practices. This topical discussion will provide an opportunity to share wisdom and experiences with graduate admissions practices.

AAPT and the Societies Consortium on Sexual Harassment in STEMM's "Roadmap Towards Excellence & Integrity in STEMM" 10–11 a.m.

Moderator: Beth Cunningham, AAPT

Soceities Consortium on Sexual Harassment in STEMM (science, technology, engineering, mathematics and medicine) was created in late 2018 following the release of a National Academies of Sciences, Engineering, and Medicine report on the impact of sexual harassment of women in academic STEMM. The mission of the Societies Consortium is "to support academic and professional disciplinary societies in fulfilling their mission-driven roles as standard bearers and standard setters for excellence in STEMM fields, addressing sexual harassment in all its forms and intersectionalities." AAPT is one of the inaugural members, joining the Societies Consortium in early 2019. The Societies Consortium provides resources such as model policies and community building to positively change culture or individual beliefs and conduct to prevent sexual harassment and promote ethics, diversity, inclusion, and equity.

The Societies Consortium created a resource, the "Roadmap Towards Excellence & Integrity in STEMM," to provide societies with a three-phase approach to supporting efforts to create more inclusive STEMM fields. The roadmap outlines a flexible course – a continuum or matrix of action – that can be pursued incrementally or concurrently, according to each society's unique needs and place on the road toward inclusion. The roadmap will be discussed during the session to determine the potential courses of action that AAPT might take in its journey to be more inclusive."

AAPT AWARDS

Presider: Chandralekha Singh

Homer L. Dodge Distinguished Service Citation Award and AAPT Summer Fellows

Homer L. Dodge Distinguished Service Citation Award:

AAPT has announced that Alexis V. Knaub will receive the association's Homer L. Dodge Citation for Distinguished Service to AAPT.

The 2021 Summer Fellows are:

Dan Burns, Cabrillo College, Aptos. CA

Doug Brown, Los Gatos High School in Los Gatos, CA

Alexis V. Knaub

Wednesday, August 4
11 a.m.–12 p.m.

Doc Brown Futures Award: Ramón Barthelemy

Barthelemy earned his BS in Astrophysics at Michigan State University and his MA and PhD in Physics Education Research at Western Michigan University. He received a Fulbright Fellowship at the University of Jyväskylä, in Finland in 2014 and a AAAS Science Policy Fellowship in 2015. He is also the recent recipient of two National Science Foundation grants to continue his work on gender in physics but also expand it to people of color in STEM and graduate program reform.

He began his position as an assistant professor of physics and astronomy (P&A) at the University of Utah in 2019. He is the first tenure track PER faculty hired in P&A at "The U" and has begun their first PER research group, the Physics Education Research Group at the University of Utah (PERU). Barthelemy also teaches courses in calculus based introductory physics and physics education.

His involvement with AAPT has included serving on the Committee on Women in Physics and organizing sessions for that committee as well as the Committee on Diversity. He was one of the early advocates for LGBT+ voices in AAPT, leading discussions and organizing the first AAPT session on the topic. He is also one of the authors of the APS report "LGBT Climate in Physics: Building an Inclusive Community."

Ramón Barthelemy

Session: PS.F-WE-01 21st Century Physics in the Classroom — Wednesday, August 4, 12:30–1:45 p.m

Sponsor: Committee on Physics in High Schools **Presider:** *Shane Wood*

PS.F-WE-1.01: Implementing Positive Psychology in International Physics Masterclass with LHC Data

Contributed – Rahmat Rahmat, SCC

Additional Author | Sau Kuen Yam, SCC

We would like to discuss our experiences in implementing Positive Psychology to improve students' engagement in International Physics Masterclass with LHC Data. We used several online tools to improve learning process, such as: Kahoot!, Zoom Polls, visual simulations, etc.

PS.F.WE-1.02: Fun Before Physics

Contributed – Charles Couch, St.Thomas Episcopal School

I have had great success teaching 11th grade and first year college level physics. My philosophy "if it is fun and/or fascinating then students IQs increase by at least 33%." Example: Astronaut Training is a 4 week lesson plan (I wrote the book which we use in my class) I conduct after the classical mechanics lessons have been taught. Topics: - orbital mechanics which includes the theory and implementation of an actual mission from Cape Canaveral to the Moon.
Once computed a world class orbital simulator is used to complete the mission to prove if the computations are correct.
- rocket design and launch which includes relevant theory for design snd launch with and without wind. A world class simulator is used. The students then create their rockets which are launched at JSC in Houston. The simulators are free. My book provides the lesson plans, exercises, simulator and build instructions.

PS.F-WE-1.03: Understanding Exotic Gravitational Wave Orbits with Effective Potentials

Contributed – Shane Larson, Northwestern University

Monica Rizzo, Northwestern University

Brett Bolen, Ben Holder, Steven Pakiela, Grand Valley State University

A promising sources of gravitational waves for the LISA observatory are "extreme mass ratio inspirals" (EMRIs) : compact stellar mass objects falling into a massive black hole. These sources are important probes of the astrophysical dynamics in the nuclear star clusters of galaxies, as well as provide detailed spacetime maps of the black hole (analogous to satellite geodesy around the earth). EMRIs are expected to have high eccentricities, and when the periapsis dips very near the black hole exhibit an orbit phenomenon known as "zoom-whirl" behavior, where rapid near-circular "whirls" are followed by a "zoom" out to apoapsis. Zoom-whirl behavior can be intuitively understood in the context of effective potentials, which should be familiar to students from classical mechanics. We demonstrate and explain zoom-whirl orbits using effective potential theory around Schwarzschild black holes, and demonstrate a public tool for visualizing EMRIs, suitable for use in a variety of classroom settings.

PS.F-WE-1.04: Instructional Implications of Introducing Quantum Physics in the Secondary Classroom

Contributed – Zac Patterson, The Ohio State University

Lin Ding, The Ohio State University

Prior research indicates that secondary students perceive quantum physics as a complex version of Newtonian physic. This raises implications for instruction as quantum physics rests on a set of principles that differ drastically from Newtonian physics. The topic need not be complex, but it does require a conceptual framework for interpretation that is incompatible with Newtonian physics. Research shows that this topic can be introduced in a purely conceptually manner but requires careful guidance from the instructor and necessitates a conceptual shift in students from a Newtonian physics framework. As topics like wave-particle duality and quantum technology find more room in physics curriculum, developing appropriate instructional approaches for this realm will become increasingly important. This paper focuses on the implications associated with introducing quantum physics principles in the secondary classroom and the epistemological challenges that arise during instruction on this exciting, yet challenging subject.

Session: PS.F-WE-02 Effective Practices in Educational Technology III — Wednesday, August 4, 12:30–1:45 p.m

Sponsor: Committee on Educational Technologies **Presider:** *TBA*

PS.F-WE-2.01: Interactive Google Doc Worksheets for Introductory Physics

Contributed – Andrew Duffy, Boston University

With the switch to teaching remotely in the pandemic era, we pivoted from a printed workbook to interactive Google doc worksheets that students work on in groups during class time. We plan to continue using these worksheets even when we return to in-person classes. Google docs offer several advantages over printed worksheets, including the ability to make edits on a just-in-time basis. They also give students various options for using them, such as the ability for an entire group to share the same document, or the ability to download them in PDF form so that students can annotate them on a tablet. It is also easy to embed editable diagrams and animated gifs. We will share examples of the worksheets during the talk, and provide a link to our entire worksheet collection, covering most of the standard algebra-based introductory physics sequence.

PS.F-WE-2.02: Group Project in an Online World? Yes, It Works!

Contributed – Kathryn McGill, University of Florida

One challenge (of many) I faced in moving my ~100-student in-person introductory physics course online was how to effectively integrate a group project into the curriculum. I needed a project that would serve as a collaborative stepping-stone to a broader view of physics, as well as a project that would be manageable to execute and grade in an online setting. Enter the team anthology, a team-based learning technique described by Elizabeth F. Barkley, Claire H. Major, and K. Patricia Cross in their book on collaborative learning techniques. I will share the constraints I faced with my particular class, as well as the adjustments to the idea I made in implementing it in the virtual Spring 2021 semester.

PS.F-WE-2.03: 16-Spinor Non-linear Field Realization in Faddeev-Skyrme Model

Contributed – Ahmed AL-Baidhani, Institute of Physical Research and Technologies

We investigate the structure of charged topological solitons in the nonlinear 16-spinor model's lepton field, using the closed-string approximation at small distances. The magnetic moment, spin, and mass of the unit leptonic number soliton configuration are calculated. The model is based on the well-known 8-spinor identity proposed by Brioschi, an Italian geometer. The Dirac current tends to be a time-like 4-vector due to its identity, allowing one to add a special form of the Higgs potential based on the current squared. The Higgs mechanism to realize the normal classification of baryons and leptons in this model. The effect of spontaneous symmetry breaking arising due to the unique structure of the Higgs potential in the model, this remarkable identity allows one to realize lepton states. Small excitation of the vacuum at large distances from the particle – soliton satisfies Klein – Gordon equation with some mass, allowing correspondence with quantum mechanics.

PS.F-WE-2.04: Is It Time to Abandon the Calculator?

Contributed – James Gerald, Delta State University

Any instructor working one-on-one with a large number of students has realized that most students have poor calculator skills. That deficit, along with the wide variety of calculators, makes it difficult to provide useful skills training without being able to exam exactly what calculations the student is performing. We've employed a methodology with two different groups of students using Microsoft Excel that enable concrete and specific feedback to students. The classes involved include a general education Physical World course and a more complex Physics for Aviation class. Both classes were offered online. In the general education course, students completed our standard pre/post assessment. In both classes, we also asked that the students complete a self-assessment of their learning gains. Those results along with details of our feedback methodology will be reported here.

PS.F-WE-2.05: Engaging Students with Escape Room Activities

Contributed – Ting-Hui Lee, Western Kentucky University

Escape room activities have become popular recently for engaging students in a classroom. The students are given clues to solve a series of puzzles that are related to the course concepts. In the process of solving the puzzles, students also use their critical thinking and teamwork skills. While using real locks and boxes could give a more authentic experience, the cost of those make it not always feasible in a large class. I used Google Forms to provide digital locks to make these activities more accessible. When the classes were moved online due to the pandemic, I modified the entire activity so that it can be run inside the Blackboard online Learning Management System. I will discuss my experience using these platforms and the students' experiences with these escape room activities.

PS.F-WE-2.06: Remote vs. In-Person Learning: Perceptions vs. Outcomes in Introductory Physics

Contributed – Michael Ecklund, United States Military Academy at West Point

Annie M Arauz, Andrew W. Boyle, Carolann Koleci, Peter H. Chapman, United States Military Academy at West Point

How do student perceptions about introductory physics correlate, if at all, with student performance, in both remote and in-person learning environments? Previous studies offer an interesting link between students' perception of the value of the course and their performance: students with lower perceived value at the start of the semester perform better in in-person learning environments, as compared to those offered remotely. Furthermore, no discernible difference in performance between remote and in-person learning environments was detected for students having higher perceived value of a course. These observations suggest that individual student perceptions are more indicative of performance than modality of instruction. We address the interplay between student perceptions and performance outcomes, in introductory physics at West Point. The following people are also part of the research team and co-investigators: J. Herrera, E. Bell, S. Hoak, V. Coghlan, D. Phillips

PS.F-WE-2.07: Improving Student Understanding of Thermal Equilibrium with an Interactive Tutorial*

Contributed – Alexandru Maries, University of Cincinnati

Kathleen Koenig, University of Cincinnati

Robert Teese, Rochester Institute of Technology

In the past few years, we have been developing Interactive video-enhanced tutorials (IVETs) which include web-based activities that lead students through a solution using effective problem-solving strategies. The IVETs, which are designed by incorporating multimedia learning principles, are adaptive and provide 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 Thermal Equilibrium and present results from implementing it in a calculus-based course taught online in the past year.

*Work supported by the NSF IUSE Program (DUE #1821396)

PS.F-WE-2.08: Lights, Camera, Action! From IOP Physics Coach to Youtuber

Contributed – Rachel Hartley, Institute of Physics

In March 2020, the Institute of Physics moved its teacher CPD online, after over a decade of visiting schools in the UK and Ireland. We had to move quickly to offer remote support and respond to the new pressures that teachers were facing. The IOP coaching team worked in much closer collaboration and learned a lot from each other, we are very lucky to have a team of over 60 active teachers. There were many deep conversations and a lot of new thinking about what physics pedagogy is vital and lends itself to a short video structure. Our live support sessions have been adapted to a blended approach with pre-recorded videos. Which ideas have made it back into the physics classroom and what works better on camera than in real life? The session includes the greatest hits of the 11-19 Domains CPD videos which you can find on IOPSpark.

Session: PS.F-WE-03 Integrating Computation into High School Physics

Wednesday, August 4, 12:30–1:45 p.m

Sponsors: Committee on Educational Technologies, Committee on Physics in High Schools **Presider:** *Danny Caballero*

PS.F-WE-3.01: Integrating Computational Jupyter Notebook Lessons into High School Physics

Contributed – Enrique Arce-Larreta, West High School DOD STEM Ambassador

Jupyter Notebooks gaining popularity in Universities for scientific computation and programming. Jupyter Notebooks utilize Python programming and are primarily used to handle large data sets. They are also used in scientific computational projects, such as machine learning. Advantages for the educational setting include: it is free to use (with a google account), its enabled to be highly collaborative (like google docs), and has the ability to allow advanced code markup including writing equations, inserting hyperlinks, youtube videos and other media. I developed six Jupyter Notebook lessons introducing high school physics students to computational physics, aimed at teaching them to graph data and solve problems. The large data sets used included the open data repository from the CMS experiment at CERN, where students can access real data to discover a particle. In addition to discussing and applying a sample lesson, problems and successes from the experience will be shared.

PS.F-WE-3.02: Modeling and Measuring Characteristics of a Large Amplitude Physical Pendulum

Contributed – Dan Burns, PASCO scientific

Large amplitude pendulums are often ignored by introductory physics classes even though students often notice deviations from the small angle approximation during physics labs. Using Blockly coding built into PASCO software, students can create models of the motion of a large amplitude pendulum from basic physics principles. The new PASCO scientific Meter Stick Torque Set coupled with rotary sensors and photogates allows for accurate measurement of angular position, angular velocity, and period. This enables students to compare their models to direct measurements to test and refine them. Methods to predict and measure the period of a meter stick oscillating about its end will be demonstrated. Code to predict the motion of the pendulum as a function of time will be shown and the results compared to measurements. A procedure for the experimental derivation of the parallel axis theorem using this equipment also will be shared.

PS.F-WE-3.03: High School Physics Teachers Online Participation in Computational Waves Class

Contributed – Sailakshmi Kumar, Texas A&M University-Commerce

Bahar Modir, Robynne Lock, William G. Newton, Texas A&M University-Commerce

With the intended goal of promoting computational thinking, Texas A&M University-Commerce offered a nine-week long summer course on Computational Waves – part of the new online Master of Physics with Teaching Emphasis (MPTE) program for in-service high school physics teachers. Using Community of Practice Theory (CoP), this study qualitatively analyzes the online discussions from the course to gauge and locate patterns of participation. We found that the primary emergent themes fell under two categories – learning to code and learning to implement computational thinking in high school pedagogy.

PS.F-WE-3.04: Introducing STEPP: A Resource for Physics Classrooms Utilizing Computational Thinking

Contributed – Mary Urquhart, University of Texas at Dallas

Midori Kitagawa, Michael Kesden, Paul Fishwick, University of Texas at Dallas

Rosanna Guadagno, Stanford University

STEPP (Scaffolded Training Environment for Physics Programming) is a no-cost interactive instructional tool designed to support the teaching of kinematics and Newton's Laws of Motion in high school physics. Developed through NSF's STEM+C program, STEPP focuses on the overlap between physics and computational thinking. STEPP allows users to model and visualize the motion described in physics problems already in their curriculum without any formal programming experience expected or required. Carefully designed with scaffolded levels and dynamic display of motion and graphing, STEPP will be available for use in classrooms this fall at stepp.utdallas.edu. Join us to learn about STEPP and how to access resources including a video workshop introduction.

PS.F-WE-3.05: Introducing Finite State Machine based Modeling into High School Physics

Contributed – Midori Kitagawa, University of Texas at Dallas*

Mary Urquhart, Michael Kesden, Paul Fishwick, University of Texas at Dallas

Rosanna Guadagno, Stanford Univerity

Scaffolded Training Environment for Physics Programming (STEPP) project team has developed a synergistic learning environment for high school physics students to acquire physics concepts and computational thinking (CT) through formative experiences modeling and simulating kinematics using modeling tools based on state diagrams called Finite State Machines (FSMs). Scaffolding and dynamic modeling with FSMs allow students to focus on the aspects of CT that support physics learning, e.g., problem decomposition, abstraction, and algorithms, instead of the aspects that are mainly about programming. Three STEPP learning modules have been developed on 1D/2D kinematics and the Newton's Laws of Motion using Unity game engine that is free for academic use and widely used in K-16 education and educational research. Each level of each module is designed for students to model a mechanics problem as an FSM and see the simulation result as an animation, graphs, numbers and equations which are all synchronously displayed.

*Sponsor: Dr. Mary Urquhart.

PS.F-WE-3.06: Dispositions and Mindset in Computation-integrated Physics

Contributed – Paul Hamerski, Michigan State University

Daryl McPadden, Marcos D Caballero, Paul W Irving, Michigan State University

High school physics classrooms across the United States are moving towards computation-integrated approaches to teaching and learning physics. Little is known about how students may enact different identities when learning physics while using computation as a tool. This study examines the case of one high school physics class where students do computation-integrated physics in a group work format. We investigate how students take up different identities and position themselves socially during class. From this data, we build a framework to describe the identities at play in this context. We aim to make researchers and practitioners more aware of the impact of implementation and the meanings behind group work interactions in computation-integrated physics. This could help practitioners prompt certain kinds of interactions either in class or via curriculum design to open up opportunities for students to take up certain identities that may help them engage productively with computation-integrated physics.

PS.F-WE-3.07: Vertical Integration of Computation into the Physics Curriculum

Contributed – Jay Wang, UMass Dartmouth

Integration of computation and modeling into the physics curriculum has been a defining trend at college level, and increasingly so at high school level. Computation not only enhances active learning and student engagement, it also prepares students with valuable computational thinking and skill sets to be successful in the STEM workforce. Unlike introductory physics where there is broad consensus in the subject matter and level of preparation, there is little such consensus on computation and modeling. In this presentation we will discuss integration of computation into the physics curriculum at UMass Dartmouth (see some examples at https://jwang.sites.umassd.edu/). We hope to stimulate conversations on shared experiences and common ground in computation including goals and preparations between high school and college levels.

PS.F-WE-3.08: The STEMcoding Object Tracker

Contributed – Chris Orban, Ohio State U. / STEMcoding Project

Analysing direct measurement videos has become a key way that we help students understand the ideas of physics, especially as instructors have switched to distance and hybrid learning. Many software programs exist to facilitate this but some include object tracking and others do not. Some of these programs work through the browser and on chromebooks while others do not. The STEMcoding object tracker is a javascript program that runs in the browser that can do object tracking on pre-recorded video data. The tracking works if the student records a brightly colored object like a bouncy ball moving in front of a black backdrop. This is a simpler approach to object tracking than most other programs use. Students must modify one line of code to help specify the color of the moving object. For more info: http://go.osu.edu/objecttracker

PS.F-WE-3.09: Developing and Applying a Computational Thinking Framework in Introductory Physics

Contributed –Theodore Bott, Department of Physics & Astronomy, Michigan State University

Daniel P Weller, Paul W Irving, Department of Physics & Astronomy, Michigan State University

Marcos D Caballero, Department of Physics & Astronomy, Michigan State University, CREATE for STEM Institute, Michigan State University, Department of Physics & Center for Computing in Science Education, University of Oslo, Oslo, Norway

Computational Thinking (CT) has recently become an important practice to study due to its inclusion in the NGSS framework. In response to calls for further investigation into CT, we developed a robust six-category, fourteen-practice framework of CT practices specific to the context of computationally integrated introductory physics classrooms. The development of the framework was guided by a comprehensive literature review of existing research around CT and an emergent coding of in-class data. The application of previous literature to our specific context highlighted the substantial influence that context can have on how CT practices manifest. The framework was applied to two different classrooms to examine differences between the CT practices that occurred between groups and activities within a classroom. We also demonstrate the ability for this framework to answer multiple questions around curriculum design that involves computational integration. This work was support by the National Science Foundation (DRL-1741575).

PS.F-WE-3.10: Computational Science with 9th Grade Physics Students*

Invited – James Gell, Plymouth High School

Computational methods have proliferated as part of introductory physics classes at the university level. The Integrating Computational Science Across Michigan (ICSAM) program run by Michigan State University is targeted at bringing those computational practices to secondary science classrooms. The initial implementation focused on students enrolled in AP Physics 1 (mostly 12th grade students) building computational models using the mathematical physics models developed from experiments. Lessons learned from the experience in AP Physics 1 were then applied to 9th grade students when the school adopted a "Physics First" curriculum and made physics a required class. There was a concern that mathematics skills of the 9th grade students would make implementation of computation physics especially challenging. In practice, we have found that the younger students were able to create computational models almost as well as the older students.

*This work was supported by the National Science Foundation (DRL-1741575).

Session: PS.F-WE-04 Lecture/Classroom

Wednesday, August 4, 12:30–1:45 p.m

Sponsor: AAPT **Presider:** *TBA*

PS.F-WE-4.01: Using Arms to Represent Complex-Valued Vectors in Quantum Mechanics

Contributed – Kelby Hahn, Oregon State University

Elizabeth Gire, Oregon State University

The Paradigms at OSU team developed a representation for complex numbers where students use their arms to embody an Argand diagram. By grouping students, the Arms Representation can be expanded to represent complex-valued vectors. The Arms Activity Sequence utilizes this expanded form to enable groups of students to represent quantum mechanical state vectors. In this talk we will present the Arms Representation and the Arms Activity Sequence. We will discuss how the sequence supports a spins-first approach by starting with complex numbers, advancing through two- and three-state systems, considering time-dependence, and eventually extending to approximate wavefunctions. The Arms Representation exemplifies the complex nature and geometric definition of a quantum state. We will highlight the development of these and other mathematics and physics concepts in the sequence and provide pedagogical tips for its implementation.

PS.F-WE-4.02: Comparing and Contrasting College Students at Different Institutions

Contributed – Kristine Lui, Swarthmore College

Efforts to increase diversity and inclusion in the learner population accessible to PER studies compel us to study student populations at all types of institutions. Having extensive experience at a two-year college, and a teaching gig at an elite liberal arts institution, I will present my observations of students' similarities and differences in these two classrooms. My aim is to continue conversations on ways in which we can broaden the impact of PER findings by incorporating observations from a wider population of students.

PS.F-WE-4.03: Designing a Physics Course Sequence for Construction Management Majors

Contributed – Jon Gaffney, Utica College

I am currently designing a sequence of two physics courses specifically for construction management majors. The first version of the sequence, taught in the academic year 2020-2021, was done using a traditional 3-hour lecture and 3-hour lab model with some students face-to-face and others joining the class remotely. Beginning in the academic year 2021-2022, the course will be taught exclusively on-ground in a brand new flexible classroom space with built-in technology, similar to a SCALE-UP classroom. We will meet 3 times per week for 2 hours each day, using an integrated lecture/lab format. In this talk I will discuss some of my experiences from this past year, the opportunities that will come with the new classroom, and the unique challenges facing the development and implementation of this particular course.

PS.F-WE-4.04: Bernoulli Misunderstood and the Jumping Coin

Contributed – Martín Monteiro, Universidad ORT Uruguay

Mateo Dutra, Instituto de Física, Facultad de Ciencias, Universidad de la República, Uruguay

Álvaro Suárez, Consejo de Formación en Educación, Montevideo, Uruguay

Arturo C. Martí, Instituto de Física, Facultad de Ciencias, Universidad de la República, Uruguay

A popular topic in physics courses and outreach, is Bernoulli equation. It follows that the higher the speed, the lower the pressure; a well-known result, but one that is often misapplied because the conditions under which this derivation is valid are not considered. A classic experiment in which this principle is invoked is to blow a coin to make it jump into a cup. To show that higher speed does not necessarily imply lower pressure, we propose to carry out an experiment with a coin placed in a hole, in such a way that the upper face of the coin is flush with the surface. We also propose a quantitative experiment to measure the upward force on the coin, for different thicknesses. That way it's verified that force increases with thickness and that force is zero when the thickness is zero, that is, when the air flow is not deformed.

PS.F-WE-4.05: Energy Transformations with Utah FORGE: Keys to Sustainable Energy Solutions

Contributed – Tamara Young, University of Utah

Utah FORGE is an international field laboratory that is managed by the Energy & Geoscience Institute, University of Utah, and sponsored by the Department of Energy, with the aim of establishing rigorous, reproducible solutions that make geothermal energy production possible anywhere beneath the surface of earth. In collaboration with the College of Education, I have been working with Utah FORGE to create NGSS aligned lessons that are relevant to this mission. In this presentation, I will share a lesson on Engineering Energy Transformations that will include explorations in energy transformations in order to engage students in developing sustainable energy solutions.

Session: PS.F-WE-05 Pandemics, Wars, Catastrophes: Their Impact in the History of Physics Wednesday, August 4, 12:30–1:45 p.m Sponsor: Committee on History & Philosophy of Physics Presiders: *Jill Macko, Steven Maier*

PS.F-WE-5.01: Mass Extinction Caused by Gravitational Instability inside the Earth*

Invited – John Baumgardner, Liberty University

The Rayleigh-Taylor instability involving accelerated fluid layers with differing densities is well known in fluid physics. A similar instability can arise within the silicate mantles of terrestrial planets because they are typically hot in their interiors and cold at their top boundaries. The strength of the instability is enhanced by the fact that the strength of silicate minerals is a strong function of shear stress and temperature. The instability is expressed by portions of the upper and lower boundary layers detaching to form plume-like diapirs that move through the mantle to the opposite boundary. This talk will present both illustrative numerical examples and observational evidence that it has occurred in the Earth's past and is responsible for a major mass extinction. The Magellan mission to Venus in the early 1990's documented that a catastrophic episode of mantle instability had also occurred within Venus in the relatively recent past.

*This invited talk is sponsored by Jill Macko.

PS.F-WE-5.02: Most Valuable Cargo: The Tizard Mission in World War II

Invited – Bradley McCoy, Azusa Pacific University

During the Battle of Britain in 1940, the British sent a top secret mission under the leadership of Henry Tizard to the United States carrying what was later described by historian John Phinney Baxter III as "the most valuable cargo ever brought to our shores." The cargo was a suitcase full of scientific and technological secrets and one working cavity magnetron, which helped seal the alliance between Britain and the United States, spurred wartime technical breakthroughs, and greatly helped to win the war. In this talk, we will examine some of the key secrets shared by the Tizard mission, including the Whittle jet engine, a system for radar defense, and a proposal on the feasibility of nuclear weapons. We will also explore the historical ramifications of this astounding sharing of secrets across borders spurred by the dire exigencies of war, and draw lessons for the COVID-19 pandemic and future crises.

PS.F-WE-5.03: Past/Present: Does the Doomsday Clock Keep the Right Time?

Invited – Katherine Pandora, University of Oklahoma

In 1947 the Bulletin of the Atomic Scientists debuted "the doomsday clock" icon as a symbolic representation of how close humanity was to self-annhiliation in the nuclear age. Initially set at 7 minutes to midnight it has been changed 22 times up until the present. There are multiple issues with the "minutes to midnight" framework that are crucial to examine: to what extent a relic of the cold war has relevance today; the ramifications of the "doomsday clock" being a key exemplar of the physics community as public educators across multiple generations; and the presumption that the rhetoric of catastrophism is needed to motivate non-scientists to be cognizant of serious issues raised by scientific research and technological developments. Understanding this history has been made even more urgent today as background to the decisions the scientific community makes about how to communicate with the public about the issue of climate change.

PS.F-WE-5.04: Learning with Objects

Invited – Allison Marsh

Museums are uniquely positioned to tell stories through objects, including the histories of pandemics, warfare, and catastrophes. But students need to learn how to "read" them. Just as we learn to analyze a text of successfully complete an experiment, students need to learn how to examine an object to understand its manufacture and use. This paper will highlight three objects from leading museums to explore what histories can be told in three-dimensions. It will also explore what stories are difficult to tell using museum collections due to past curatorial choices – what stories get left out of history because their artifacts have not been deemed worthy. This paper is based on my work as a curator with the Smithsonian Institution and as a writer of the "Past Forward" monthly column for IEEE's Spectrum.

Session: PS.F-WE-06 PER: Curriculum and Instruction II Wednesday, August 4, 12:30–1:45 p.m. Sponsor: AAPT Presider: *TBA*

PS.F-WE-6.01: Diverse Strategies for Design Physics Activity by Investigating Research-based Activities

Contributed – Amin Bayat Barooni, Georgia State University

Stephen Ross Scoular, Brian D. Thoms, Joshua S. Von Korff, Georgia State University

Jacquelyn J. Chini, University of Central Florida

To support physics instructors in improving or modifying physics activities for their courses, we investigate sixty-six research-based activities from eleven different research-based curricula by applying k-means cluster analysis. The best results were found when the program generates three design clusters. We mark these clusters as Thinking like a Scientist, Learning Concepts, and Scientific Reasoning. These three clusters indicate different design goals. In the Thinking like a Scientist cluster, activities emphasize the design of experiments by students, error analysis, reasonableness checking, and making assumptions or simplifications. The Learning Concepts cluster focuses on the prediction of results and experimental observations. The scientific reasoning cluster emphasizes answering physics or math questions that do not use collected data and finding evidence by students to support their claims.

PS.F-WE-6.02: Examining the Dynamics of Decision Making When Designing Curriculum in Student Partnerships

Contributed – Erin Sohr, University of Maryland College Park

Ayush Gupta, Mithibai College

Brandon J Johnson, University of Maryland College Park

Gina M Quan, San Jose State University

Common models of curricular development often involve hierarchical relationships between researchers and students, where researchers lead the design and testing of curriculum for students. Several years ago, informed by work in Students as Partners, we began to undertake curriculum design in partnership with students. We invited undergraduate physics students to participate in a team tasked with codesigning quantum mechanics tutorials. In this presentation, we will summarize an analysis of one interaction in which researchers attempted to create space for students to contribute to decision making around the codesign process. Through analyzing interactional dynamics, we describe how access to decision-making was opened up and/or cut off to students and how the interactional dynamics often contested or reaffirmed participants' roles. We aim to self-critically reflect on the challenges and tensions that emerge in facilitating codesign partnerships. We discuss our own areas for growth and speak to implications for more responsible partnerships.

PS.F-WE-6.03: Characterizing Active Learning Environments in Physics using Latent Profile Analysis

Contributed – Kelley Commeford, Drexel University

Eric Brewe, Drexel University

Adrienne Traxler, Wright State University

Active learning has been shown to be more effective than passive lecture methods, but we have yet to establish a vocabulary with which to characterize different active learning methods. We investigated six active learning curricula in physics using the Classroom Observation Protocol for Undergraduate STEM (COPUS), which codes student and instructor activities in two minute intervals. We then used latent profile analysis on the resulting COPUS profiles to determine if these curricula could be sorted into similar groups based on common classroom features. We present our findings and discuss how latent profile analysis can be used to further the goal of describing active learning independently of lecture methods.

PS.F-WE-6.04: Assessing a Flipped Lab Course Consisting of Open-Inquiry Projects Using Arduinos

Contributed – Forrest Bradbury, Amsterdam University College

Freek Pols, Delft University of Technology

We will describe two iterations of a fully open lab course in which natural science students (N=15,20) conceive, design, and carry out two extended experiments using open-source materials. A flipped-style is used whereby students set up experiments and take measurements without supervision, allowing the instruction time to focus on the more difficult parts of their empirical research cycles. In our analysis, we explore the merits and trade-offs of this radically open approach, whereby student agency is prioritized over the quantity and scientific quality of the inquiries. In student projects, initially unforeseen constraints or unexpected results usually require changes to the experimental design and sometimes even force students to alter their research questions. Happily, students make demonstrable progress towards becoming critical and independent researchers, especially in the conception and iterative design of their experimental methods. We also describe interdependencies amongst the open-inquiry and flipped-classroom teaching methods and the accessible open-source materials.

PS.F-WE-6.05: Learning Basic Physics Skills via Regular Online Mastery Practice

Contributed – Andrew Heckler, Ohio State University

The Essential Skills learning application has been iteratively developed for over 7 years and implemented as a regular weekly assignment with over 10,000 students at the Ohio State University for the algebra and calculus-based introductory physics course and the second-year physics major course. The assignments include mastery practice of basic skills such as trigonometry, algebra, vector math, and calculating work and torque. These skills are practiced multiple times throughout the semester to improve accuracy, fluency, and retention. We report on data showing that students typically increase on all of these factors throughout the semester, and we also find some evidence of transfer for hierarchical sets of skills. Though we will report on some pilot studies on potential benefits on exam performance, there are still open questions as to how or whether improvements on basic skills are helping to achieve larger scale and more complex instructional goals.

PS.F-WE-6.06: Effect of PhET Simulations in a General Education Physics Course

Contributed – Jeffrey Rosauer, Department of Physics, Illinois State University, Normal, IL

Katie Crook, Department of Physics, Grant Kaufman, Raymond Zich, Department of Physics, Illinois State University, Normal, IL

This study investigated the impact of an instructional intervention on student scientific reasoning skills and general attitudes toward science. The intervention consisted of nine PhET simulations introduced to a general education physics class. Students manipulated the simulations while completing worksheets testing their comprehension of the concepts and the scientific reasoning being displayed. Completion of each PhET simulation activity took students about 50 minutes to complete. Lawson's Classroom Test of Scientific Reasoning was administered to assess improvement in student scientific reasoning skills, and the CLASS was used to assess changes in student attitudes towards science. Pre-to post Lawson results show gains in scientific reasoning. CLASS pre to post indicated overall shifts to expert-like responses. Qualitative data in the form of student surveys was collected and showed approval of the use PhET simulations in the class.

PS.F-WE-6.07: Building Nuance in Classroom Conversations about Ethics, Science, and Society

Contributed – Brianne Gutmann, Texas State University

Alexander Vasquez, Daniel Barringer, Alice Olmstead, Texas State University

Conversations around the interactions of ethics, science, and society within STEM classrooms provide opportunities for students to practice large-scale ethical reasoning in the context of their future careers. We have designed and implemented curricular units which help instructors to scaffold these conversations in Texas State University STEM courses, including Modern Physics and Observational Astrophysics. We have collected and analyzed video data and written work in these course contexts. Our analysis has demonstrated that students' scaffolded considerations of different stakeholder groups can build empathy and deepen their understanding of the broader context for ongoing ethical issues. We also see that students' characterization of stakeholder groups' motivations and identities can grow in complexity and nuance. In this talk, I will use classroom video and other artifacts to illustrate some examples we have identified where we see students building nuance and consider lessons for supporting students' engagement with complex ethical issues in physics.

PS.F-WE-6.08: Introducing the New Paradigms in Physics Curriculum Website

Contributed – David Roundy, Oregon State University

Elizabeth Gire, Tevian Dray, Corinne A Manogue, Oregon State University

The Paradigms in Physics website provides a wide range of tested active engagement activities for upper division courses. Our team has been redesigning this site to add considerable "mortar" content between activities and to make the content more readily searchable. We have also been working to make it easier to keep the content fresh, and to give users a clearer perspective of how we use our own materials. The features of the new site will be introduced, and we will solicit audience feedback on how the site will be introduced, and we will solicit audience feedback on how the site could better serve you.

Session: PS.F-WE-07 PER: Diversity, Equity & Inclusion IV Wednesday, August 4, 12:30–1:45 p.m.
Sponsor: Committee on Research in Physics Education Presider: *Joseph Kozminski*

PS.F-WE-7.01: Do Admissions Metrics Predict PhD Completion Indirectly Through Graduate GPA?

Contributed – Michael Verostek, University of Rochester

Ben M Zwickl, Casey W Miller, Rochester Institute of Technology

Graduate admissions committees are slowly ending the use of GRE scores due to concerns that they restrict access to underrepresented groups but have limited predictive utility. Similar to previous analyses of PhD completion, this study uses common admissions metrics such as undergraduate GPA (UGPA) and GRE scores to predict PhD completion. Now, using statistical methods recently advocated in causal inference literature, a counterfactual mediation framework is used to determine whether these metrics directly predict PhD completion or indirectly predict completion via an intermediate variable (graduate GPA). Consistent with prior work, results show that UGPA is a stronger predictor of completion than Physics GRE scores. However, the analysis reveals that these effects are fully mediated by graduate GPA, suggesting that admissions metrics are not directly measuring characteristics needed to complete a PhD. Rather, they are measuring traits linked to graduate course performance that in turn affect graduate attrition.

PS.F-WE-7.02: An Introduction to Critical Race Theory for Physicists

Contributed – Miguel Rodriguez Velazquez, University of Utah

Race continues to play a major role in American society which is made evident by racial gaps in wealth, healthcare, and law enforcement. Systemic racial oppression continues to thrive in both secondary and post-secondary education, resulting in more obstacles for students and scholars of color. As a result, there is a lack of representation of people of color in the field of physics among other STEM disciplines. We will highlight some of the current issues of racism within education using the theoretical framework of Critical Race Theory (CRT). CRT has deep roots in legal studies and was created for understanding and transforming the relationship between race, racism, and power. Using CRT, we will critically examine why these systemic forms of oppression exist, how they propagate, as well as what we can do to combat them and support racial minorities in our community.

PS.F-WE-7.04: Intersection of Spirituality/Religiosity and Physics Identities for Black Physics Students

Contributed – Saeed Moshfeghyeganeh, Florida International University

Jafr Tayar Shabazz, Joinee Taylor, Zahra Hazari, Florida International University

Spiritual/religious individuals are underrepresented in physics. Considering that spirituality/religiosity play a salient role in the life of students of color, especially the Black students, we investigate the intersection of spiritual/religious identities of Black physics students with their physics identity. In this study we interviewed Black physics students to understand how their spiritual/religious identities informed the choice of physics and interact with other kinds of identity like gender to affect how they see themselves as physicists.

PS.F-WE-7.05: Integrating Science and Social Issues in the Introductory Physics Curriculum

Contributed – E. Prasad Venugopal, University of Detroit Mercy

In recent years, there has been growing awareness of the need for inclusive physics curricula to help address the lack of diversity and representation in the field. Integrating social issues into the physics curriculum has the potential to "change the culture of science to be more welcoming and inclusive" [https://underrep.com/] by broadening the cultural contexts in which scientific knowledge is created and practiced. In this presentation, I discuss a multi-week introductory physics assignment for which students were required to read The Boy Who Harnessed the Wind, by William Kamkwamba and Bryan Mealer, and to respond to the scientific and social issues in the story. Kamkwamba's autobiographical narrative of his construction of a windmill is suffused with introductory physics concepts embedded in an intense social context of poverty, famine, deforestation and climate change in his native Malawi. The talk will discuss project details, as well as student responses to the assignments.

PS.F-WE-7.06: Student Storytelling of Physicist Profiles to Promote Physics and Diversity

Contributed – Roberto Ramos, University of the Sciences

I will report on my experiences in promoting student storytelling of the lives of physicists as part of course requirements in lower and upper division college physics courses. The primary objective was to motivate and expand the understanding of physics beyond the concepts and equations by contextualizing discoveries and understanding what motivated the study of physics in the lives of real people. Students are required to dig into the lives of physicists and unusual historical or contextual situations encountered in their lives and discoveries and relate stories they find interesting. A special effort was made to promote story-telling of the background and contributions of women and minorities in physics. Students also learned vital skills in producing short youtube videos up to 5 minutes long. I will report on student responses and reactions to this effort, based on general observations and results of blind surveys.

PS.F-WE-7.07: Strength-based Analysis of Experiences of Physics Students with ADHD

Contributed – Kaleigh Salty, Texas State University

Eleanor W Close, Texas State University

Attention-Deficit/Hyperactivity Disorder (ADHD) has been the subject of a growing body of psychological and recently, neurological research. The majority of this research has been behavioral and deficit-oriented, focused on "coping" and ways of controlling ADHD behavior to function within institutional norms. This focus persists despite compelling evidence that physiological variations are responsible for ADHD behavior, over which "control" is limited and institutional "functionality" becomes discriminatory. This is evidenced by the lack of scientific works examining ADHD from a positive perspective [1]. In this study, we analyze interviews of physics students and faculty at Texas State University (a large Hispanic-Serving Institution) who have been diagnosed with ADHD. The focus of these interviews is on interviewees' experiences in physics, and their self-perceptions of strengths and capabilities that may be unique to the interviewees' variant neurobiology or their life experience as members of a marginalized academic group.

[1] Edward M Hallowell and John J Ratey, Delivered from Distraction: Getting the Most out of Life with Attention Deficit Disorder (New York: Ballantine Books, 2006).
Soheil Mahdi et al., "An International Qualitative Study of Ability and Disability in ADHD Using the WHO-ICF Framework," European Child & Adolescent Psychiatry 26, no. 10 (March 28, 2017): 1219–31.
Holly A. White and Priti Shah, "Creative Style and Achievement in Adults with Attention-Deficit/Hyperactivity Disorder," Personality and Individual Differences 50, no. 5 (April 2011): 673–77.
Holly A. White and Priti Shah, "Uninhibited Imaginations: Creativity in Adults with Attention-Deficit/Hyperactivity Disorder," Personality and Individual Differences 40, no. 6 (April 2006): 1121–31.

Session: PS.F-WE-08 Physics on the Road and the Art of Demonstration Wednesday, August 4, 12:30–1:45 p.m.

Sponsor: Committee on Science Education for the Public **Presider:** *Tatiana Erukhimova*

PS.F-WE-8.01: Livestreamed Lessons: Experiences of Delivering a Virtual STEM Festival

Contributed – Dawson Nodurft, Texas A&M University

Ryan Carmichael, Geoffrey Franceschi, Ryan Mueller, Tatiana Erukhimova, Texas A&M University

The ongoing pandemic has forced many organizations to adapt presentation styles and delivery methods to a virtual environment to reach their audiences. The Texas A&M Physics and Engineering Festival was no exception to this reality. Reaching an audience of thousands of people virtually to provide interactive, entertaining physics demonstrations and talks from speakers in remote locations requires a combination of audio-visual equipment, computer equipment, software, and the right team to deliver a high quality event. Experiences, technical knowledge, and lessons learned in the process of creating this event will be shared and discussed.

PS.F-WE-8.02: Virtual Physics Demonstration Videos – A Primer

Invited – David Maiullo, Rutgers University

Producing videos of physics demonstrations for the virtual classroom st should be a fairly straightforward process. The truth is, as usual, more complex. As Rutgers had gone entirely virtual since the start of Summer 2020, classes, I had been tasked with the process of building an online video physics and astronomy collection, now around 300, so that our physics and astronomy instructors can "cherry pick" the ones they'd like their students to view to help learn and understand the classroom topics. I'll review how to produce an effective and interesting video and the methods anyone could use to store and disseminate them. I'll also touch on the use of "slow motion" and other effects, sound options and quality, and when split screen could be useful. I'll finish with a discussion of what do do with your videos now that we seem to be migrating back to "in person" instruction.

PS.F-WE-8.03: Show it to U.S.

Invited – Stanley Micklavzina, The University of Oregon

Science outreach is an international phenomenon. I have had the privilege of being a part of Science Festivals in various countries in the EU, and through those festivals, witnessed and interacted with other incredible science presenters from around the world. At a science festival in Slovenia, the organizers have a special session called Show It to Others, where the invited presenters have 5 minutes to share something they have created to demonstrate science with the other presenters. Given that this talk is being done remotely, I have asked my international colleagues to become part of this remote presentation and submit to me, a short description of their program that also features an example of their work. I am excited to share a glimpse of these creative presenters to the AAPT membership.

PS.F-WE-8.04: Keeping the Best Parts: Learning from Online Demos and Activities

Invited – Marc 'Zeke' Kossover, Exploratorium

Desiré Whitmore, Exploratorium

What does the Exploratorium's Teacher Institute which specializes in hands-on activities do when our audiences go online? Adapt. We found activities that used only common materials teachers and students would have at home. Then, we examined what could be included in simple kits handed out or put in the mail. Finally, we reexamined some of our notions about what we thought doing an activity should be like. For example, maybe it's not only okay if everyone's materials are different, maybe it's better. Learn the permanent changes that the lockdown is leaving behind on how we do activities even in person.

PS.F-WE-8.05: STEM Through the Screen: Experiences of Adapting Community Outreach

Invited – Alex Evans, Leicester City in the Community*

How can you successfully deliver community STEM outreach when face-to-face opportunities are limited? And how can you best support the most vulnerable and underrepresented members of your community through virtual STEM education? During this talk, you will hear of our experiences in adapting our existing outreach programmes and crafting new virtual programmes to suit the evolving educational needs of young people in Leicester, as well as our recommendations for effectively utilising virtual STEM engagement for years to come.

*Sponsor: Sarah Johnson.

Session: PS.F-WE-09 The Art and Science of Teaching Wednesday, August 4, 12:30–1:45 p.m.

Sponsor: Committee on Physics in Undergraduate Education **Presider:** *Andy Gavrin*

PS.F-WE-9.01: Teaching a Computationally Integrated Quantum Physics Course Online

Invited – Marcos Caballero, Michigan State University

At Michigan State University, we have been integrating computational modeling into our majors' courses including in Classical Mechanics, Electromagnetism, and Quantum Mechanics for the last several years. As we have moved to online learning as a result of the ongoing COVID-19 pandemic, we have had to shift computational instruction to a fully online format. In this talk, I will detail the design of a computationally integrated Quantum Mechanics course that has been offered fully online. Quantum Mechanics is a keystone of physics education - students learn how to approach sophisticated models and non-classical ways of thinking all while developing their mathematical toolbox. In this presentation, I will outline learning goals, course activities, and assessments. In addition, I will offer advice for how some elements of this course might continue as we return to in-person instruction.

PS.F-WE-9.02: The Value and Logistics of Student Submitted Videos for Homework

Invited – Andy Rundquist, Hamline University

Instead of written homework, I collect videos of students doing and explaining their work. I'll talk about why I do this, the value of seeing the process in addition to the product, and the logistical problems and solutions I've come across. I do this for small and big classes, lectures and labs, theory and coding. The biggest upsides are a much better understanding of the students' understanding along with a dramatic reduction in cheating. Typical videos are 3-5 minutes in length and I watch them at double speed. This allows me to grade up to 1000 videos per class per semester.

PS.F-WE-9.03: Equity-oriented Classroom Practices

Invited – Geraldine Cochran, Rutgers University

Course transformations, course design/redesign, and modification of curricular materials in physics have been motivated by a variety of things. In this presentation, I will discuss equity-oriented course development. I use equity-oriented to refer to activities and practices that are aligned with reducing the impact of existing injustices in education and tailored to the specific needs of the population being served in the classroom. In some cases, pedagogical practices designed to advance equity in education have failed due to misalignment with the needs of the students. To illustrate this, I will provide examples of pedagogical practices that can contribute to equity or exacerbate historical injustices in education when implemented in different settings and with different populations.

PS.F-WE-9.04: Labs in Intermediate Mechanics: Combining Student-Made Videos with Computational Modeling

Invited – Deva O'Neil, Bridgewater College

The Classical Mechanics course taught at BC in Fall 2020 used a hybrid model of class instruction, combining students learning remotely and students attending in person into a single synchronous class. Past offerings of this course used hands-on lab experiments to engage students in mathematical modeling of oscillators and other mechanics topics. To give all the learners a uniform experience, lab experiments in 2020 were replaced with group video analysis projects, integrating lecture, experiment, and computation. The videos were used to scaffold increasingly nuanced computational models. For example, for oscillations, student videos of everyday objects oscillating were solicited and exploited as a "hook" to introduce modeling of undamped springs, and the discrepancies between theory and experiment were used to motivate damped models. This structure was inspired by Brian Lane's "Capture, Code, Compare" activities.

Session: PS.F-WE-10 Tips and Tricks for Publishing in AAPT Journals: The Physics Teacher and the American Journal of Physics

Wednesday, August 4, 12:30–1:45 p.m Sponsor: Committee on Professional Concerns Presiders: *Beth Parks, Gary White*

PS.F-WE-10.01: TPT Highlights from a Challenging Year

Invited – Gary White, AAPT and The George Washington Univ.

Looking back, it has been a year like no other for *The Physics Teacher*. I will shine a spotlight on some of our recent content such as the exciting collection of articles on sex, gender, and physics teaching, while also reflecting on some of the metrics we use to measure what we produce. In addition I will attempt to convey some glimpses of possible future feature items in *TPT*.

PS.F-WE-10.02: Submitting a Manuscript to The Physics Teacher

Invited – Pamela Aycock, The Physics Teacher Journal

The Physics Teacher focuses on teaching introductory physics at the high school, two- and four-year college, and university levels. Typical topics include innovative physics demonstrations, new ways of doing lab experiments, ideas for presenting difficult concepts more clearly, suggestions for implementing newer technology into teaching, historical insights that enrich the physics course, and suggestions for using results from physics education research, all focused on teachers in the introductory physics classroom. I'll discuss our newest process for submitting manuscripts and what to expect after you submit your work.

PS.F-WE-10.03: Publishing in the American Journal of Physics

Invited – Beth Parks, American Journal of Physics / Colgate University

AJP publishes articles of interest to university-level physics instructors, normally beyond introductory level topics. Many of the papers will be directly applicable in the classroom or laboratory, and others are valuable for the insight they provide to instructors. I'll discuss the broad categories of papers that we publish, what we're looking for in a manuscript, and what to expect after you submit your work.

PS.F-WE-10.04: Using Japanese Animation (Anime) for Teaching Fluid Mechanics

Invited – Sangjin Ryu, University of Nebraska-Lincoln

Haipeng Zhang, Markeya Peteranetz, Tareq Daher, University of Nebraska-Lincoln

Visual pop culture has been employed for physics education because novel examples from visual pop culture can capture students' attention. Although widely enjoyed by people around the world, Japanese animation (Anime) has been used less frequently than other types of visual pop culture. In this presentation about our recent paper published in "The Physics Teachers", we introduce how Anime examples can be used to teach fluid mechanics concepts including buoyant force, drag, lift, and key dimensionless numbers such as Reynolds number. This approach was employed in an undergraduate-level fluid mechanics class, and many students were positive about using Anime for teaching fluid mechanics because the examples provided a break from the normal methods of teaching and students were more engaged with the content that they learned. Therefore, Anime has the rich potential as a source of instructional examples that illustrate concepts from fluid mechanics and other areas of physics.

PS.F-WE-10.05: Key Biology you Should have Learned in Physics Class

Invited – Daniel Zuckerman, Oregon Health & Science University

I will discuss the following abstract of a published AJP paper, along with some considerations that went into planning the manuscript. The biological cell exhibits a fantastic range of behaviors, but ultimately these are governed by a handful of physical and chemical principles. Here we explore simple theory, known for decades and based on the simple thermodynamics of mixtures of ideal gases, which illuminates several key functions performed within the cell. Our focus is the free-energy-driven import and export of molecules, such as nutrients and other vital compounds, via transporter proteins. Complementary to a thermodynamic picture is a description of transporters via "mass-action" chemical kinetics, which lends further insights into biological machinery and free energy use. Both thermodynamic and kinetic descriptions can shed light on the fundamental non-equilibrium aspects of transport. Our biochemical-physics discussion will remain agnostic to chemical details, but can help us understand cellular "fuel" ATP.

PS.F-WE-10.06: Ya Basic: Examining the Duality of Minority-Serving Conference Experiences

Invited – Xandria Quichocho, Michigan State University & Texas State University

Identity affirming conferences in physics are a massively useful space for individuals from minoritized and marginalized backgrounds to build community and develop physics identity in a safe environment. However, not all conferences are built and experienced in the same way. This paper aims to critically examine the conferences experiences of individuals who live in the intersections of race, gender, and sexuality through their narratives. I draw on identity development research being done at Texas State University, as well as narratives gathered from Twitter in order to build a story about the exciting and transformative (the dope) experiences at conferences, and the ones that left us feeling a little empty (the basic). I apply a critical lens to the experiences of minority students who have attended these conferences to examine the ways the events support their holistic identities or fail to do so.

PS.F-WE-10.07: Surface Charges from a Sensing Pixel Perspective

Invited – Maurice Klee

Surface charges direct the flow of current through conductors. In anthropomorphic terms, they tell the current where to go and where not to go. As acknowledged by Professors Griffiths, Jackson, and Chabay and Sherwood, surface charges have been difficult to calculate. This paper presents a new way to calculate surface charges in which the surface of the conductor is covered with pixels which hold the surface charge. The pixels (referred to as "sensing pixels") sense the electric fields produced by all the other charges in the system and adjust their internal charge until steady state is reached. Importantly, sensing pixels allow students (and researchers) to understand why surface charge distributions, however calculated, look the way they do by asking the simple question: "What would a sensing pixel sense?" As Professor Sherwood kindly wrote to the author, this can make such counterintuitive phenomena as the accumulation of charges at edges, intuitive.

PS.F-WE-10.08: The Elephant in the (Class)Room: Discussing Gender Inequality in Physics

Invited – Livvy Eickerman, Whitman College

Moses Rifkin, University Prep

In this paper, we discuss gender inequality in the physics classroom. Diversity strengthens science, but in most physics classrooms female students are disadvantaged both directly and indirectly: extensive research shows that they are undermined, viewed as less capable, and have less successful experiences both in terms of learning and identity formation. In this article, written in partnership between a male high school physics teacher and a female student from his 2018-2019 12th-grade physics class, we describe a two-week period in which we worked together to try to change the culture of our physics class.

Session: PS.F-WE-11 PER: Student Content Understanding, Problem-Solving and Reasoning IV

Wednesday, August 4, 12:30–1:45 p.m. Sponsor: AAPT Presider: *TBA*

PS.F-WE-11.01: The Conceptual Development of Student Understanding of Weight

Contributed – Xiangqun Zhang, Zhenjiang Experimental School*

Lei Bao, The Ohio State University

Existing research has reported persistent difficulties among students at all levels in understanding the concepts involving weight and gravitation. In the literature and textbooks, there are two versions of weight definition in terms of (1) the gravitational force applied on an object and (2) the force applied on the supporting object. The latter is often referred to as the operational definition of weight, which describes the process of weighing an object. Studies have also demonstrated that using the operational definition in teaching can improve student understanding of the concepts involving weight, gravitation, and weighing. However, in the Chinese middle school physics curriculum, the gravitational definition of weight is mandated and universally implemented in instruction. To investigate the impact on student learning from using the gravitational definition of weight, a post-instruction survey is conducted to examine students' conceptual understandings of weight. The results will be discussed and compared to the literature.

*Sponsor: Lei Bao

PS.F-WE-11.02: Electric Charge as a Signed Quantity

Contributed – Alexis Olsho, University of Washington

Suzanne White Brahmia, University of Washington

Trevor I Smith, Rowan University

Andrew Boudreaux, Western Washington University

Reasoning about the concept of electric charge, and the meaning of the term "net charge" in particular, presents a greater learning challenge than students and instructors might initially recognize. This may be due in part to subtleties in the use of positive and negative signs to characterize complementary charges, rather than to indicate that the quantities are greater than or less than zero. In this talk, we discuss the nuances of electric charge as a physical quantity and situate it in a body of work by mathematics and physics education researchers to characterize the uses and meanings of signs. We then describe preliminary research that illustrates the effect of wording differences on student reasoning about electric charge as a signed quantity, and discuss implications for instruction.

PS.F-WE-11.03: Making Dual Nature of Human Reasoning More Explicit During Instruction*

Contributed – Alistair McInerny, North Dakota State University

Mila Kryjevskaia, North Dakota State University

Andrew Bourdreaux, Western Washington University

Reasoning consistently across contexts is a challenge in learning physics. Even students who demonstrate correct conceptual understanding and reasoning on one task often fail to use the same knowledge and skills on related tasks. Observed inconsistencies can be accounted for by dual-process theories, which assert that human cognition involves two thinking processes: the heuristic, which is fast and automatic, and the analytic, which is slow and deliberate. Inconsistent responses arise when the heuristic process produces an intuitively appealing (but incorrect) response that the analytic process fails to reject. We speculated that instruction that makes the dual nature of human cognition explicit and more visible to the students could help them recognize and evaluate intuitive responses more productively. We will present the results of a study designed to probe the impact of such instruction on student learning in introductory calculus-based mechanics courses.

*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

PS.F-WE-11.05: A Dual Process-based Teaching Intervention for Terminal Speed*

Contributed – Andrew Boudreaux, Western Washington University

In accounting for the terminal speed behavior of a falling object, it can be challenging for students to coordinate the quadratic drag force model with the Fnet=0 condition. On some questions, students seem to reason in ways inconsistent with force balance ideas they have successfully applied in related contexts. We have used dual process theories of reasoning to interpret for such responses, and also to guide design of an intervention. This talk will present the intervention, link elements of the intervention to dual process theory, and share preliminary results.

*Based on work supported by the National Science Foundation under Grant Nos. DUE-1821390, DUE-1821123, DUE-1821400, DUE-1821511, DUE-1821561

PS.F-WE-11.06: The Mixed Messaging of Algebraic Variables in Physics

Contributed – Suzanne White Brahmia, University of Washington

Andrew Boudreaux, Charlotte Zimmerman, Alexis Olsho, University of Washington

Mathematics education researchers have been investigating for decades – in math contexts – student understanding of the many uses of algebraic variables. Physics, with its alphabet soup of symbolic representations of quantities and constants, takes this variation in variable use to a whole new level. There is a growing body of evidence from physics education researchers suggesting that student difficulty with manipulating variables presents a barrier to succeeding in physics. The context dependence of symbol use in physics is nuanced, and often not part of students' mathematics preparation. In this talk we present evidence that the presence of a single variable significantly affects the outcome in even simple quantitative questions for students in calculus-based introductory physics. We present a framework, adapted from mathematics education, for thinking about the various roles that algebraic variables play in physics contexts. We present recommendations for instruction to help students conceptualize these uses.

PS.F-WE-11.07: Collaborative Mechanistic Reasoning in a Learning Assistant Preparation Session

Contributed – Shahrzad Hesaaraki, Texas State University

Austin C McCauley, Jessica Conn, Eleanor W Close, Texas State University

A large body of research supports the positive impact of interactive instruction on student learning. The mechanism for this increased student learning, however, is less well understood. We propose collaborative mechanistic reasoning as a possible mechanism for this enhanced learning. In this research, we analyze video episodes of small group work during weekly LA preparation sessions, using a discourse analysis framework developed by Russ et al. (2008) to identify elements of mechanistic reasoning. This framework allows us to identify episodes of high-level mechanistic reasoning in LA discussion. In our analysis, we are focused on the highest level of mechanistic reasoning, chaining. We will present analysis of an episode of collaborative chaining in terms of the mechanistic reasoning discourse analysis framework.
*This material is based upon work supported by NSF #1557405

Sense-Making by Manipulating Apparatus and Using Gesture

Contributed – David Brookes, California State University, Chico

Peter Bohacek

Eugenia Etkina, Rutgers, The State University of New Jersey

Anna Karelina, St. Mary's College of California

Matthew Vonk, University of Wisconsin, River Falls

What role does experimental apparatus play as a semiotic resource and what do students do when the apparatus is replaced with a video of the same experiment? In this talk, we will examine this question in the context of a quasi-experimental study where we examined how students developed scientific reasoning abilities using video-based experiments as compared to students who conducted the same experiments with physical apparatus. In comparing the affordances and constraints of each environment (video-based experiments versus apparatus-based experiments) we discovered interesting patterns in students' sense-making behaviors
a. When equipment was present, it served as a key semiotic resource in sense-making.
b. Students in the video-based condition also engaged in sense-making without equipment. When they did, their verbal sense-making was accompanied by extensive use of gesture. We will present case studies from our research and discuss the broader implications for supporting students' sense-making in different contexts.

Session: PS.F-WE-12 High School — Wednesday, August 4, 12:30–1:45 p.m.

Sponsor: Committee on Physics in High Schools   Presider: *TBA*

PS.F-WE-12.01: Identity Development Through Diverse Encounters

Contributed – Marianna Ruggerio, Auburn High School

The formation of a "physics identity" is critical for students to enroll, persevere and pursue further physics education. This physics identity is often weaker in underrepresented populations in physics. The COVID pandemic opened the possibility for students to encounter a wide diversity of physicists though livestreams and webinars. This presentation will discuss leveraging these opportunities to help build and create a physics identity in underrepresented students in an urban-emergent school.

PS.F-WE-12.02: Facilitating Authentic ISLE Instruction in a Virtual Environment

Contributed – Danielle Bugge

Eugenia Etkina, Rutgers University

The Investigative Science Learning Environment (ISLE) approach to learning and teaching engages students in learning physics in a collaborative environment where they actively construct and apply new knowledge. How does this hands-on, student-centered approach to learning transfer to a virtual platform? Are students able to effectively engage in the practices of physicists and do they feel good about themselves as learners in the process? In this talk, we report on the findings from a survey administered to high school teachers that utilized the ISLE approach in their classrooms prior to the transition to virtual learning. We ask them how they modified their instruction including what resources they used, how they assessed student understanding, whether or not they felt their students were able to learn, and what changes (if any) need to be made for this to be effective for future or different groups of learners.

PS.F-WE-12.03: Teaching Physics Using Agricultural Concepts

Contributed – Diedre Young, University of Arkansas System Division of Agriculture Cooperative Extension Service

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

Arkansas is primarily an agricultural economy with billions of dollars accrued through crop production. Because of this, agriculture should be represented in Arkansas classrooms and in national education as agronomy requires a broad range of STEM trained graduates. Teachers can introduce basic physics concepts such as fluid flow and thermodynamics using real world agricultural scenarios and in-class demonstrations such as measuring water amount in soil to demonstrating the effect of water evaporation in irrigation systems (and the resultant cost of such). As a cross cutting concept, soybeans are cultivated to be used in the implementation of this lesson to determine water evaporation which includes discussion of soybean transpiration. The concepts and examples presented can easily be modified for any science classroom using locally used crops.

PS.F-WE-12.04: PEER Physics: Open Source Waves Unit

Contributed – Valerie Otero, University of Colorado Boulder

General, conceptual, and "Physics First" instructors are often isolated and left to either adapt advanced curricula or piece together resources. PEER Physics provides a robust NGSS-aligned curriculum and a community for teachers to connect and learn about implementing science and engineering practices. Students are immersed into the discipline of physics through anchoring phenomena that drive their curiosity while they make and defend claims. This evidence-based reasoning is supplemented with argumentation and consensus building where the whole class generates a set of broadly-applicable principles. Materials have been carefully developed and tested with input from practicing teachers, physics content and pedagogy experts, and instructional coaches. This unique collaborative effort has led to a physics program that is unlike anything else available for high school general and conceptual physics. In this presentation, we will share about our newly released open source Waves chapter, and the accompanying phenomenon, engineering design challenge, and 3D-assessment.

PS.F-WE-12.05: Effect of Self-Regulated Learning Worksheets on Student Understanding of Vectors

Contributed – Voltaire Mistades, De La Salle University

Maricel DLC Briones-Sumanghid, Santa Rosa Science and Technology High School, Laguna, Philippines

The COVID-19 pandemic challenged teachers to implement emergency remote teaching in delivering their lessons. Various strategies had been developed by Physics teachers to engage students in meaningful learning of the lesson. This paper presents the effect of using self-regulated learning (SRL) worksheets on Grade 9 students' understanding of vectors. In developing the worksheets, the three phases of self-regulation -- forethought, performance, and self-regulation -- were integrated in the worksheet design to guide the students. The students' worksheet output indicated an improvement in the students' understanding of vectors. Journal logs and student interview revealed that the students had a positive experience with the use of the SRL worksheets.

PS.F-WE-12.06: Pushing the Limit: Students Rising to the Challenge

Contributed – Edward Berliner, Marsha Stern Talmudical Academy

Over the decade, I have applied the syllabus of a First Year University College course toward Instructing High School Juniors in AP Physics C Mechanics and E&M (Calculus based). As these students are enrolled in Calculus I concurrently (have not yet fulfilled the pre-requisite), I must creatively teach them concepts and applications of differentiation, integration, and differential equations "on the fly." Rather than struggling, the students consistently rise to the occasion and attain success in understanding and mastering advanced topics not normally expected of High School students (e.g., I use imaginary exponentials to help them solve SHO problems with damping). I will present anecdotal evidence from Physics Faculty at the University associated with the High School that the students are not only superbly prepared, they "trounce the curve" and are encouraged to skip First Year Physics. I will also present Student evidence as to their satisfaction and enhanced confidence.

S.F-WE-12.07: STS Approach in High School from Brazil

Contributed – Arivaldo Lopes, UNICSUL- Brazil

The research took place in a public school in Brazil (São Paulo) involving 183 students of the second year in High school. The Physics's contents are: Astronomy, Calorimetri, Termodinamics and Optics. The didatical intervention had Games, experiments, seminars and debates. The goals are identify 10 competences according to the Nacional Base to Basic Education in Brazil, the knowledge in Physics and some STS goals. The instruments to take data are the field diary, the student's assignment, questionnaire and interview. The research is qualitative and use the metod intervention-research. The data analysis show development of the 10 competences in more or less intensity, Physics knowledge acording to the local curriculum and change in behaviors and attitudes to understend the impactos of Science, Technology in the Society, like the environmental degradation.

PS.F-WE-12.08: Seeing Reality Through Einstein's Eyes: A Proposal for Special Relativity

Contributed – Alessio Mattia Leonardi, Roma Tre University

Settimio Mobilio, Roma Tre University

Claudio Fazio, University of Palermo

Special Relativity is a critical issue in the teaching of physics in the Italian high school. The theory does not show daily examples, thus preventing the possibility of structuring simply laboratory's experiences. In this talk, we present the results of an experimentation regarding the teaching of Special Relativity. The main innovation of our project consists of a mechanical instrument we use to explain Special Relativity. This tool is a big spacetime diagram in which each event on the grid can be moved along certain hyperbolas-shaped tracks, that represent the surface of constant interval. Thus, one physically and mechanically performs Lorentz's transformation by hands, exploring the effects of a change of the reference frame. Teachers and students can deal "by eye" with unusual phenomena as the loss of simultaneity, times dilation, lengths contraction, relativistic addition of velocities and Doppler's effect which are the main topics of interest for High Schools.

PS.F-WE-12.09: The Physics of Living Systems Teachers (PoLS-T) Network

Contributed – Isaura Gallegos, Harvard Graduate School of Education

Robert Krakehl, Stony Brook University/ Manhasset Secondary School

Greg Morrison, University of Houston Dept of Physics

Eric Mazur, Harvard University Dept of Physics

Secondary school physics teachers often teach out-of-field, out-of-certification and are often the only physics teacher in their school. As a result, physics teachers lack support in developing pedagogical content knowledge. The Physics of Living Systems - Teacher (PoLS-T) network was established in 2020 to address salient challenges in secondary physics classrooms, within a community of practice of high school teachers and education researchers. In the year since its founding, the PoLS-T network has met on a monthly basis to discuss the needs of physics teachers, focusing on existing online resources they could leverage, and disseminating evidence -based best teaching practices. Due to the network's membership, composed of both U.S.-based and international physics educators, the network has been a rich action-oriented community of practice. In our presentation, we will share key insights and future plans for the network, including the Monthly Speaker Series and other events.

2–3 p.m.

Disability Meet-up

International Meet-up

Retired Physicist's Meet-up

Student Topical Discussion & Social

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!

Organizer: Danny Doucette Doucette, University of Pittsburgh

Tweet-up

Meet your fellow Twitter users, share teaching ideas and thoughts on using Twitter in the classroom, tweet your summer meeting highlights, and have fun collaborating in an interactive virtual environment. Plus, it's a great opportunity to associate a face with a tweet.

PERC Bridging Session

Wednesday, August 4, 3–4:30 p.m

Sponsor: Committee on Research in Physics Education Presider: *TBA*