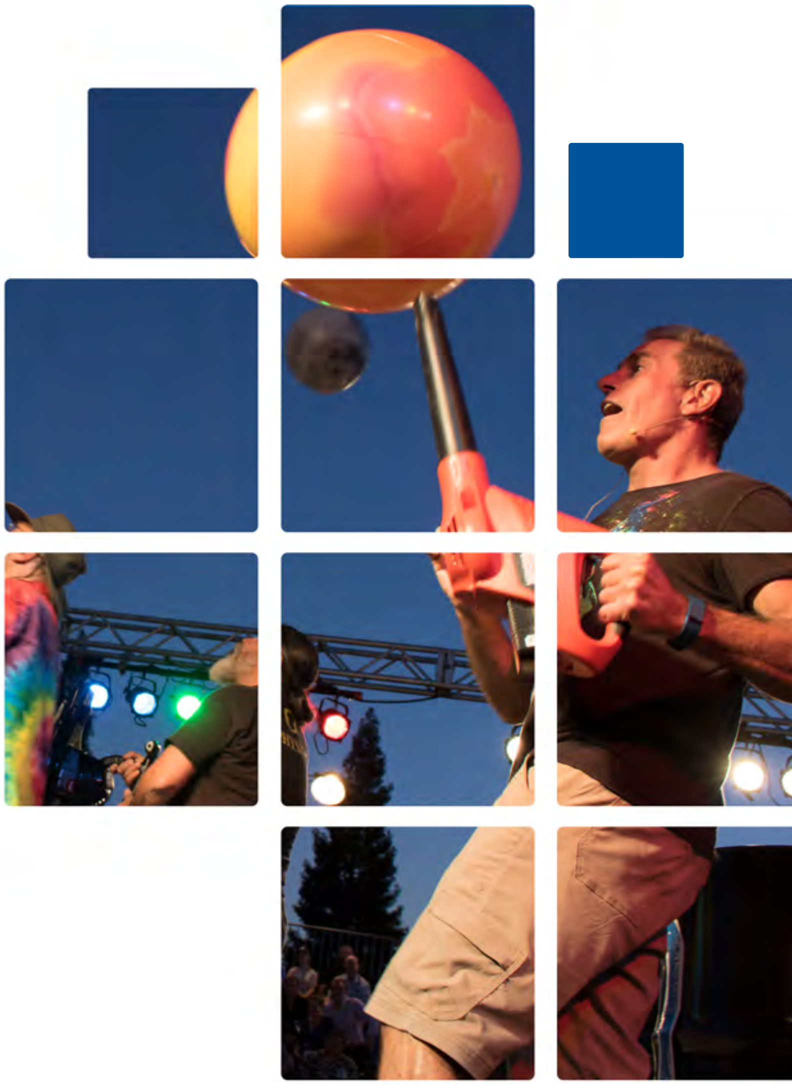
2017 AAPT Summer Meeting



AAPT
PHYSICS EDUCATION

openstax™

University

Phys-
ics

OpenStax is thrilled to announce our newly published University Physics book, a recent addition to our library of openly licensed, peer-reviewed textbooks.

Available for free online and for a low cost in print, University Physics is a three-volume collection that meets the scope and sequence requirements for two- and three-semester calculus-based physics courses.

Welcome from the 2017 AAPT Summer Meeting Program Chair

Welcome! We have a great program planned for you. The workshops will be held at the University of Cincinnati and transportation will be provided to all workshops.

The sessions, tutorials and workshops cover all interests and levels from the novice to the experienced teachers. This year's plenary talks run the gamut from medical physics to astronomy to policy outreach.

Be sure to check out the special events on the mobile app. These include the Effects of the Sun: Solar Planetarium Show (Saturday, July 22, 7:00-8:00 p.m.—buses depart at 6:30 p.m); Solar Fest (Monday, July 24, 11:30 a.m.–1:30 p.m.). Note the emphasis on astronomy, in preparation for the solar eclipse, observable on August 21, 2017, in various parts of the USA.

Cincinnati and Covington, across the Ohio River from each other, contain various points of interest. Visit or see the mobile app for a list of fun things to do. These include numerous museums, restaurants and breweries, entertainment venues and the Great American Ball Park, home of the Cincinnati Reds.

It will be an exciting and invigorating five days! I encourage you to bring your colleagues and students to future meetings and help them discover the knowledge that attending an AAPT meeting can impart. Join us in Cincinnati for the riverfront hospitality!

Welcome to Cincinnati/Covington!

Gordon Ramsey, Program Chair

Cincinnati, OH
July 22–26, 2017

Northern Kentucky Convention Center
Cincinnati Marriott at RiverCenter

AAPT American Association of Physics Teachers

American Association of Physics Teachers
One Physics Ellipse
College Park, MD 20740
301-209-3311
www.aapt.org

Meeting Information.......... 6
Committee Meetings.......... 7
AAPT Awards.......... 8
Plenaries.......... 12
Commercial Workshops.......... 14
Exhibitor Information.......... 16
Workshop Abstracts.......... 20
Session Abstracts.......... 28
Sunday.......... 28
Monday.......... 30
Tuesday.......... 79
Wednesday.......... 116
Participants' Index.......... 142
Advertiser Index.......... 145
Maps.......... 146

FIRST TIME AT A NATIONAL AAPT MEETING?

WE HAVE A DAY OF ACTIVITIES PLANNED FOR YOU ON MONDAY, JULY 24:

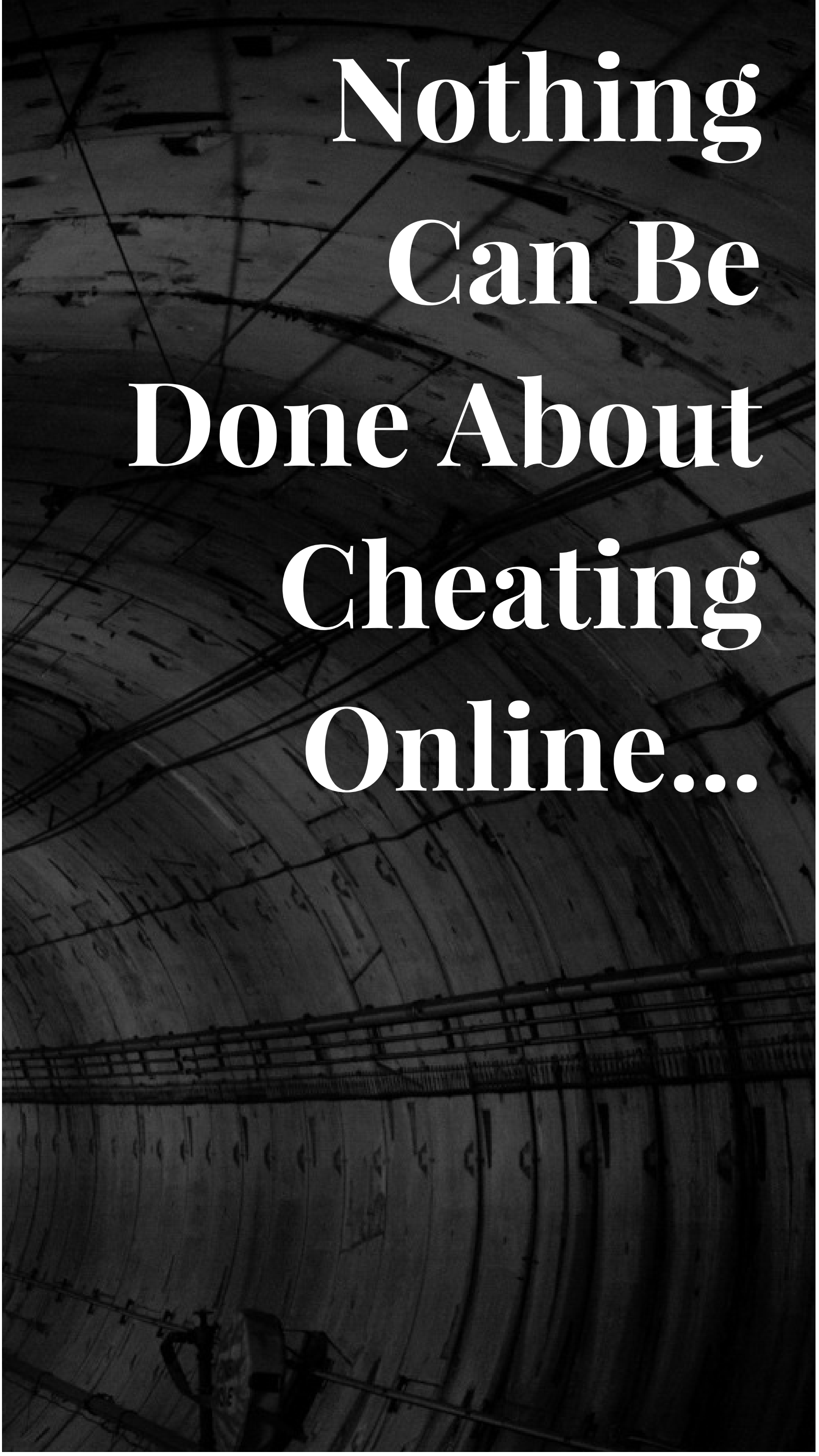
- First, meet newbies and check out what resources AAPT has to support you during the First-Timers' Gathering from 7:00 - 8:00 AM. Registration required.

- Then, our early career professionals can meet with experienced faculty and teachers at the Early Career Speed Networking Event from 12:00 - 1:30 PM.

- Finally, join us for the First Timer & Early Career Professional Social at Smoke Justis from 6:00 - 7:30 PM. Take this opportunity to get out in Covington with other attendees and have some fun! Apps provided.

Download our meetings app for more about these events and for exact event locations.

PICK UP YOUR "NEWBEE" STICKER AT AAPT's BOOTH 26 AND BE ON THE LOOKOUT FOR FELLOW FIRST-TIMER'S!



Expert TA

Commercial Workshop

theexpertta.com | 12 - 1 | July 24 | Breakout Rm. 3

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
American 3B Scientific
Andrews University Physics Enterprises
Expert TA
Klinger Educational Products Corp.
Lab4U, Inc.
Merlan Scientific
Morgan and Claypool Publishers
OpenStax College
PASCO scientific
Perimeter Institute for Theoretical Physics
PhysicsVideos.com
Physics 2000.com
Quantum Experience Ltd.
Science First
Spectrum Techniques LLC
TeachSpin Inc.
Tel-Atomic Inc.
Vernier Software
WebAssign
John Wiley & Sons

Join us for Solar Fest

Monday, July 24
11:30 a.m. –1:30 p.m.
The Landing
(outside between Marriott & Embassy Suites)

Special Thanks

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

Workshop Organizers:

Kathleen M. Koenig, Alexandru Maries, Henry Leach, University of Cincinnati

Paper sorters:

Dan Beeker, Indiana Univ. - Bloomington
Tom Carter, College of DuPage
Brad Conrad, Society of Physics Students
Marla Glover, Rossville High School
Amber Henry, LIGO
Charlie Holbrow, Massachusetts Institute of Technology
Mel Sabella, Chicago State University
Elizabeth Walker, North Cobb High School

AAPT Board of Directors

George A. Amann, President
193 Primrose Hill Rd.
Rhinebeck, NY

Gordon P. Ramsey, President Elect
Loyola University - Chicago
Chicago, IL

Mel Sabella, Vice President
Chicago State University
Chicago, IL

Wolfgang Christian, Secretary
Davidson College
Davidson, NC

R. Steven Turley, Treasurer
Brigham Young University
Provo, UT

Janelle M. Bailey, Past President
Temple University
Philadelphia, PA

Dyan Jones, Chair of Section Representatives
Mercyhurst University
Erie, PA

David E. Sturm, Vice Chair of Section Representatives
University of Maine
Orono, ME

Karen Jo Matsler, at large (4-Year College Representative)
University of Texas - Arlington
Arlington, TX

Sherry L. Savrda, at large (2-Year College Representative)
Seminole State College of Florida
Sanford, FL

Daniel M. Crowe, at large (High School Representative)
Loudoun Academy of Science
Sterling, VA

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

David P. Jackson (ex officio)
Editor, ***Amer. Journal of Physics***

Beth A. Cunningham (ex officio)
AAPT Executive Officer

Robert C. Hilborn (guest)
AAPT Associate 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 **#aaptsm17**. We will also be posting any changes to the schedule, cancellations, and other announcements during the meeting via both Twitter and Facebook. Visit our Pinterest page for suggestions of places to go and things to do in the Cincinnati area. We look forward to connecting with you!

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

Contact:

Meeting Registration Desk: 301-209-3340

N. Kentucky CC: wifi under "NKYCC – Public," no password

Committee Meetings

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

Saturday, July 22

Nominating Committee I	6–7:30 p.m.	Marriott - Kentucky
Board of Directors I	6–9 p.m.	Marriott- Riverview I

Sunday, July 23

Meetings Committee	8–10:15 a.m.	Marriott - Riverview II
Publications Committee	8–10 a.m.	Marriott - Riverview I
Board of Directors II	10:30 a.m.–4 p.m.	Marriott - Riverview 1
Programs I	5:30–6:30 p.m.	Marriott - Covington Ball. I
Section Representative and Officers	5:30–8 p.m.	Marriott - Covington Ball. II
Educational Technologies*	6:30–8 p.m.	Marriott - Riverview I
Science Education for the Public*	6:30–8 p.m.	Marriott - Covington Ball. III
Diversity in Physics*	6:30–8 p.m.	Marriott - Riverview II
Modern Physics*	6:30–8 p.m.	Marriott - Madison II
Alpha Committee*	6:30–8 p.m.	Marriott - Terrace III
Interests of Senior Physicists*	6:30–8 p.m.	Marriott - Terrace IV

Monday, July 24

Apparatus Committee	7–8:30 a.m.	CC - Breakout 1
Graduate Education in Physics*	7–8:30 a.m.	CC - Breakout 2
International Physics Education*	7–8:20 a.m.	CC - Breakout 6
Professional Concerns*	7–8:30 a.m.	CC - Breakout 9
Space Science and Astronomy*	7–8:20 a.m.	CC - Breakout 8
Women in Physics*	7–8:30 a.m.	CC - Breakout 3
PERLOC*	7–8:20 a.m.	CC - Breakout 7
Awards Committee	12–1:30 p.m.	Marriott - Terrace IV
Laboratories Committee*	6–7:30 p.m.	CC - Breakout 1
History & Philosophy of Physics*	6–7:30 p.m.	CC - Breakout 2
Research in Physics Education*	6–7:30 p.m.	CC - Breakout 6
Physics in Two-Year Colleges*	6–7:30 p.m.	CC - Breakout 3
Physics in High Schools	6–7:30 p.m.	CC - Breakout 9

Tuesday, July 25

Review Board	7:30–8:30 a.m.	CC - Breakout 1
Physics Bowl Advisory Committee	7:30–8:30 a.m.	CC - Breakout 2
Executive Programs Committee	7:30–8:30 a.m.	CC - Breakout 3
PTRA Oversight Committee	7–8:30 a.m.	Marriott - Madison I
Physics in Undergraduate Education*	12–1:20 p.m.	CC - Breakout 4
Teacher Preparation*	12–1:20 p.m.	CC - Breakout 5
Physics in Pre-High School Education*	12–1:20 p.m.	CC - Breakout 7
PIRA Committee*	12–1:20 p.m.	CC - Breakout 6

Wednesday, July 26

Programs II	7–8:30 a.m.	CC - Ballroom E
Governance Structure Committee	7–8 a.m.	Marriott - Riverview I
Venture/Bauder Endowment Committee	7–8 a.m.	Marriott - Riverview II
Finance Committee	8–9 a.m.	Marriott - Riverview II
Membership and Benefits Committee	12–1 p.m.	Marriott - Riverview I
Nominating Committee II	3:30–5 p.m.	Marriott - Riverview II
Board of Directors III	3:30–6 p.m.	Marriott - Riverview I

Robert A. Millikan Medal 2017

Kenneth Heller
University of Minnesota
Minneapolis, MN

Can We Get There from Here?

Tuesday, July 25

10:30 a.m.–12 p.m.

CC - Event Center II

Kenneth Heller is the Robert A. Millikan Medal awardee for 2017. This award recognizes educators who have made notable and intellectually creative contributions to the teaching of physics. Heller is a professor of physics at the School of Physics and Astronomy, University of Minnesota, Minneapolis, MN. After receiving his BA from the University of California, Berkeley, Heller spent two years in the Peace Corps in Kenya and Nigeria before completing his PhD at the University of Washington. Besides his roles as professor of physics and associate head of the physics department at the University of Minnesota, he has for many years been an active member of both APS and AAPT, and has organized events for both associations. He is a fellow of the APS and AAAS and is a regular presenter at the AAPT/APS New Faculty Workshops.

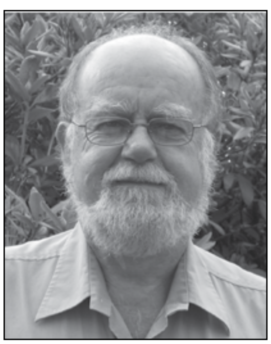
Heller is a pioneer in developing a systems approach to supporting the learning of physics through problem solving. This approach emphasizes the importance of the structure of problems including paper and pencil and laboratory problems, the structure and support of student groups, the preparation and support of teaching assistants, and the beliefs and values of faculty. Heller and his research and development group used a variety of methods to establish the research basis for the pedagogy known a Cooperative Group Problem Solving and made the technique adaptable by a wide variety of instructors and institutions.

The pedagogical systems and materials produced by his PER group are some of the most widely used research validated materials in U.S. colleges and universities. Although developed for introductory physics at the college level, this pedagogy has been influential in teaching advanced physics courses and in other STEM fields as well. The continuing work includes the use of computers on the internet as coaches and the appropriate structure and content of the introductory physics course for biology majors.

His service in support of physics education includes his role as AAPT President. He has also served on several other APS and National Academies committees related to education. For example, he was a member of the National Academies Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research. The report from this committee, released in 2012, has been highly influential in supporting the growing field(s) of Discipline-Based Education Research, of which Physics Education Research is an important part.

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. The award was established by AAPT in 1962.

Klopsteg Memorial Lecture Award 2017



John C. Brown
University of Glasgow

Black Holes and White Rabbits

Tuesday, July 25

4–5 p.m.

CC - Event Center II

John C. Brown, University of Glasgow, School of Physics and Astronomy, is the 2017 recipient of the Klopsteg Memorial Lecture Award. This award recognizes educators who have made notable and creative contributions to the teaching of physics. Brown's successful career as a solar physicist has been marked by his success at communicating science. This ability to communicate has been recognized by the Queen of the UK appointing him in 1995 as 10th Astronomer Royal for Scotland and in 2016 as an OBE (Officer of the Most Excellent Order of the British Empire) "for services to the promotion of astronomy and science education."

Brown is unquestionably one the leading astrophysicists in the United Kingdom. He has greatly enhanced progress in the important field of high energy radiation associated with solar activity, so improving our understanding of the physics of our nearest star and of the Sun-Earth system with the sometimes dramatic effects the Sun can have on our home planet. He has also worked in many other areas of astrophysics including hot star mass loss, comet collisions with the sun and stars, solar-sailed spacecraft, and ill-posed data deconvolution problems. In all of these Brown is recognized worldwide for his pioneering contributions to science, for his deep insight into the underlying physics, and for his determination to uncover truth rather than 'taking sides' on issues. Through his willingness, when demanded by the facts, to take a stance that is sometimes contrary to the popular wisdom, he has consistently striven to provide a thorough and clear exposition of the essential science and its importance. These qualities earned him Glasgow University's Kelvin Prize and Medal in 1984 and the Royal Astronomical Society's (Geophysics) Gold Medal (their highest honour) in 2012.

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.

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

Cindy Schwarz
Vassar College
Poughkeepsie, NY

What Can We Do in the Subatomic Zoo?

Monday, July 24

10:30 –11:30 a.m.

CC - Event Center II

The 2017 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching winner is **Cindy Schwarz.** John Wiley & Sons is the principal source of funding for this award, through its donation to the AAPT. Schwarz earned her BS in Mathematical Physics at SUNY at Binghamton (1980) M. Phil, in Physics at Yale University (1983), and her PhD in Experimental Particle Physics, at Yale University (1985). She is a Professor of Physics in the department of Physics and Astronomy at Vassar College. Schwarz was an early adopter of interactive teaching methods and brought many techniques, such as peer instruction, use of smartboards in the classroom, use of electronic clickers, and in-class problem solving to Vassar College and shared those methods with her colleagues. She instituted Vassar College's Physics Teacher Certification program by working closely with the Education Department in crafting a New York state-approved curriculum. She has been an active member of AAPT, and has brought students to many regional and national meetings.

For nearly 30 years, Schwarz has been an innovator in interactive pedagogies and an author of multiple books that have made an impact on physics education at the undergraduate as well as elementary and high school levels. She has been a leader and mentor to Vassar faculty members. Schwarz has created multiple new physics courses during her time at Vassar. "Physics in Motion" is a course in which Vassar students create instructional physics videos and take them into the local community where they are presented to students ranging from 3rd graders up to high school students. Schwarz is recognized for her excellent work in bringing a modern, evidence-based pedagogy to the instruction of physics at Vassar College. She has been an advocate for science literacy, finding new and exciting ways to bring physics to undergraduate non-physicists as well as K-12 students (one example is the co-authored book for 7–11 year olds, Adventures in Atomville: The Macroscope which is available in English and Spanish). She has guided many physics majors to careers as professional educators and has been instrumental in achieving a balanced gender ratio in the Physics and Astronomy Department at Vassar College. Schwarz has been a volunteer in many roles in the AAPT community including service on the Committee on Women in Physics (1991-1993), (2004-2007), the Committee of Computers in Physics Education (2001-2001), and the Committee on Educational Technologies (2010-2013).

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.

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

J. Mark Schober
Trinity School,
New York City

Sharing Your Expertise

Monday, July 24

10:30 –11:30 a.m.

CC - Event Center II

The 2017 Paul Zitzewitz Excellence in Pre-College Physics Teaching Award winner is **J. Mark Schober**, a physics teacher from Trinity School, New York City. This award is in recognition of contributions to pre-college physics teaching and awardees are chosen for their extraordinary accomplishments in communicating the excitement of physics to their students.

Schober earned his Bachelor degree in Physics, Mathematics, and Theater Arts at Concordia College in Moorhead, Minnesota, and Master's degrees in Physics and Secondary Education at Miami University in Oxford, Ohio. Schober began teaching at John Burroughs School in St. Louis where colleagues and mentors from the St. Louis Area Physics Teachers (SLAPT), the Modeling Instruction program, the National Science Teachers Association, and AAPT, inspired his classroom practice and prepared him to lead teacher workshops for each of these organizations. Serving as the webmaster for SLAPT, he also helped to formalize SLAPT's structure to become an AAPT Section. He worked with SLAPT and Six Flags St. Louis to edit and write curriculum and plan logistics for Physics Day. Schober served as President of the American Modeling Teachers Association (AMTA) as the organization grew in its role as the custodian of the Modeling Instruction program. Schober is a founding member and past Chairman of STEMteachersNYC, a grassroots professional development group "by teachers, for teachers, about teaching". Through his involvement with these groups, he has led numerous weekend and multi-week science teaching workshops for teachers across the country.

His colleague noted that "these workshops rank at the top of the professional development I have experienced in my 47 years as a teacher – the electricity and magnetism workshop was so powerful to me that it caused me to completely reformulate my course at my school to conform to the structure of the workshop."

Schober currently teaches at Trinity School in New York City where he served as department head and promoted Trinity's shift to a physics-chemistry-biology sequence. He teaches physics, engineering, and astronomy, and advises a variety of student groups.

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

Homer L. Dodge Citations for Distinguished Service to AAPT

Wednesday, July 26 • 10:30 a.m.–12 p.m. • CC - Event Center II

Joseph Kozminski

Joseph Kozminski

Joseph Kozminski earned his BS in Physics and Mathematics at the University of Notre Dame, Notre Dame, IN, his MS and PhD in Physics from Michigan State University, East Lansing, MI. He began his teaching career as a Teaching Assistant and Research Assistant at Michigan State University. In 2005 he served as Adjunct Professor at Triton College, River Grove, IL. He joined the faculty of Lewis University later that year and has continued to teach and lead the Physics Department. Kozminski has performed extraordinary service to AAPT in a variety of positions including serving as a reviewer for *American Journal of Physics*, and being a member of the Executive Committee of the Undergraduate Curriculum Task Force since 2013, and took the lead in writing the "AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum."

Duane Merrell

Duane Merrell

Duane Merrell is Associate Teaching Professor, Department of Physics and Astronomy, Brigham Young University, Provo, UT. Merrell earned his AS in Pre-Engineering at the College of Eastern Utah, BS in Education, Math, and Physics from the Utah State University, and his MS in Instructional Design from Utah State University. From 1985–2004 he taught high school at Snowflake High School in Arizona and Emery High School in Castle Dale, UT. In 2004 he accepted a position at Brigham Young University. The physics teacher preparation program that Merrell has created there has been very successful in increasing the number of new physics teachers produced each year since 2006. In addition to Merrell's leadership in the area of physics teacher preparation programs, he has played a significant role in the advancement of physics teaching in a number of other areas.

Bill Reitz

William E. (Bill) Reitz

Bill Reitz is a retired teacher from Hoover High School, North Canton, OH. He had previously taught in Scotland and Australia. Regarding his selection to receive this award, Reitz said, "It is an unexpected honor to be recognized by the organization that shaped my career and humbling to be listed among many of the physics educators who have inspired me." An active member of the Ohio Section, Reitz received the section's Distinguished Service Award in 2009. He served as the Ohio Section President from 1998-2000 and 2012-2014 and as Section Representative from 2015-2017. He first became an AAPT PTRA in 1986 and has continued to serve the physics community in that role. Additionally, Reitz has served on the AAPT Committee on Physics in High School and has chaired the Committee on Physics in Pre-High School and the Committee on Science Education for the Public.

Toni Sauncy

Toni Sauncy

Toni Sauncy is Associate Professor and Department Chair at Texas Lutheran University in Seguin, TX. Sauncy earned her BS in Mathematics (magna cum laude) at Texas Tech University, her MS in Physics at Texas Tech University and her PhD in Applied Physics at Texas Tech University, Lubbock, TX. An active member of AAPT since 1997, Sauncy has served on the AAPT Programs Committee (2013-14), the Lotze Scholarship Committee (2014-16), and the Committee on Physics in Undergraduate Education (2015-18). She has been an active Texas Section AAPT member for her entire professional career, serving through the four year presidential chain. She has also served as the four-year college representative to the Executive Council of TS AAPT. Sauncy was the Director of the Society of Physics Students (SPS) and Sigma Pi Sigma from 2012-2014 at the American Institute of Physics (AIP).

Paul Stanley

Paul Stanley

Paul Stanley is Professor of Physics and holder of the Dobson Endowed Professorship in Physics at Beloit University, Beloit, WI. Stanley earned his BS from Iowa State University and his MS and PhD from Oregon State University. He joined the Peace Corps, and spent seven years deep in the South Pacific as a high school teacher. Stanley began his work with the U.S. Physics Team in 2003 when he became a coach. He became the team's Academic Director in 2009 and has continued serving in that role. He has been very successful in developing the tests used to identify the top U.S. high school physics students, and in training them to compete in the international physics competition. More at aapt.org/about

Read more about the awardees at www.aapt.org/about

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

Julianne M. Pollard-Larkin
University of Texas, MD Anderson Cancer Center

The Future of Image-Guided Radiotherapy will be MR-Guided

by Julianne M. Pollard-Larkin

Monday, July 24 • 7:30–8:30 p.m. • CC - Event Center II

Dr. Julianne Pollard-Larkin is an Assistant Professor of Medical Physics at the University of Texas, MD Anderson Cancer Center in Houston, TX. She is the Ad-interim Service Chief medical physicist in MD Anderson's Thoracic Radiation Oncology Clinic. Dr. Pollard-Larkin also conducts clinical research and mentors and teaches Medical Physics residents and graduate students. Her primary research interests include pacemaker radiotherapy dose measurements and improving the efficacy of motion management in thoracic treatments and radiobiology.

At MD Anderson, she created a faculty support group over the last four years for the women medical physicists at her institution known as the Medical Physics Women's Group and hosts educational events with local school children to introduce them to her field.

She received her PhD in Biomedical Physics at UCLA and her B.S. in Physics and Mathematics at the University of Miami in Coral Gables, FL. After receiving her PhD at UCLA, Julianne was accepted into the Medical Physics Residency program at MD Anderson in Houston, TX. Following her residency, Julianne was hired by MD Anderson as faculty.

Beyond her role in the clinic and classroom, Julianne is a firm believer in outreach and increasing the pipeline of women and underrepresented populations in science. Every program she graduated from, she was the first and only African-American woman, she works tirelessly to see that she is not the last.

Francis Slakey
American Physical Society/ Georgetown University

The Effective Force

by Francis Slakey

Wednesday, July 26 • 10:30 a.m.–12 p.m. • CC - Event Center II

Francis Slakey is the interim Director of Public Affairs for the American Physical Society, the Upjohn Lecturer on Physics and Public Policy at Georgetown University, and author of the international best-selling adventure memoir *To the Last Breath.*

Dr. Slakey received his PhD in Physics in 1992 from the University of Illinois, Urbana-Champaign. In addition to his technical publications, has also written widely on energy policy issues, publishing more than 50 articles for the popular press including *The New York Times*, *Washington Post*, and *Scientific American*. He has given more than 150 invited talks including to the National Academy of Sciences, NASA Space Flight Center, US Strategic Command, the Library of Congress, and Microsoft. Dr. Slakey has served in advisory positions for a diverse set of organizations including the National Geographic, the Council on Foreign Relations, the International Panel on Solutions to Sustainability, and the Center for Strategic and International Studies. He is a Fellow of the American Physical Society, a Fellow of the American Association for the Advancement of Science, a MacArthur Scholar, and a Lemelson Research Associate of the Smithsonian Institution.

Dr. Slakey became the 28th American to summit Mt. Everest in an unguided environmental expedition that was the subject of the award-winning movie "Beyond the Summit". He is the first person in history to both summit the highest mountain on every continent and surf every ocean. In recognition of his adventures, as part of the 2002 Olympic Games, he carried the Olympic torch from the steps of the US Capitol.

#AAPTSM17

JOIN US FOR AN OFFICIAL TWEET-UP

MONDAY, JULY 24TH FROM 3:00-4:00 PM

MARRIOTT - RIVERVIEW BALLROOM I

Meet up with your Twitter friends and discuss how social media impacts your physics classroom. Not sure how to use Twitter? Learn from the Tweeting experts on how to use it to improve your teaching.

Snacks will be provided.

Free Commercial Workshops

CW01: Foster Learning, LLC: Teaching Problem Solving on a Tablet

Location: CC - Breakout 1
Date: Monday, July 24
Time: 12–1 p.m.
Sponsor: Foster Learning, LLC

Leaders: Tom Foster, Eddie Ackad

Teachers see problem solving as a process while students see problem solving as frustratingly difficult to memorize. It is not uncommon for students to consider problem solving as a hurdle to get over however they can, regardless of instructor's attempts to emphasize otherwise. Traditional homework delivery systems exacerbate this student misconception by only requiring and grading the answers. We have developed a tablet-based (Android, iOS) learning platform that can explicitly demonstrate a structured approach to solving nearly any mechanics problem. The platform, known as PathPlan, is based upon PER and cognitive science results about best practices for learning systematic problem-solving. PathPlan has several modalities, allowing the instructor to select the level of guidance, from full to test mode, for problems, which are graded based upon the process the student submits as well as the answer. We seek instructors who teach introductory mechanics willing to beta test PathPlan at a reduced price to their students. Please bring your own tablet (Windows requires an emulator program) to this workshop to experience PathPlan for yourself.

CW02: PASCO scientific: *Essential Physics*, the Ultimate e-Book for Physics

Location: CC - Breakout 2
Date: Monday, July 24
Time: 12–1 p.m.
Sponsor: PASCO

Leader: Brett Sackett

Meet *Essential Physics* author Dr. Tom Hsu and see how this interactive physics e-Book is the ultimate compliment to your instruction. With the *Essential Physics* e-Book, students will have all the tools they need in one location, with a common user interface. *Essential Physics* combines quality physics textbook content with 100 physics simulations, interactive equations, videos, random quiz-builder, and the Infinite Test Bank with built-in assessment. Runs on Standard browser on Mac®, Windows®, Android™, iPAD®, and Chromebook™.

CW03: PASCO scientific: How Much Physics Can You Do with the Wireless Smart Cart?

Location: CC - Breakout 2
Date: Monday, July 24
Time: 1:30–2:30 p.m.
Sponsor: PASCO

Leader: Brett Sackett

In this session we will cover Kinematics, Dynamics, Work, Energy, Impulse and Momentum experiments using the versatile Wireless Smart Cart. See how much physics you can cover with a low friction dynamics cart that accurately measures position, velocity, acceleration, force, and angular velocity. Be the first to try the newest Smart Cart accessory and blow your students' minds! You may win a Smart Cart!

CW04: PASCO scientific: Untangling Electric Circuits

Location: CC - Breakout 2
Date: Monday, July 24
Time: 3–4 p.m.
Sponsor: PASCO

Leader: Brett Sackett

See how easy teaching circuits can be using PASCO's Modular Circuits. Circuits are difficult for many students to understand because they cannot "see" the phenomenon. Conceptualizing current flow and changes in electrical potential becomes even more challenging when their circuit lab becomes a spaghetti of wires. Help your students transition from lecture to understanding with PASCO Modular Circuits. Students can easily build and understand basic circuits with our circuit design blocks. You may win a Modular Circuits Kit!

CW06: Perimeter Institute: Beyond the Atom: Particles & Neutrinos

Location: CC - Breakout 1
Date: Tuesday, July 25
Time: 12–1 p.m.
Sponsor: Perimeter Institute

Leaders: Glen Wagner, Damian Pope

Come on a journey from the Rutherford scattering experiment to today's Large Hadron Collider. This new resource advances understanding of what makes up everything in the cosmos. Explore hands-on activities that will help your students understand particle physics and neutrinos. Collaborations between PI, SNOLab, and CERN have produced this must use resource.

CW07: Introducing Pivot Interactives from Vernier

Location: CC - Breakout 3
Date: Tuesday, July 25
Time: 12–12:50 p.m.
Sponsor: Vernier Software & Technology

Leaders: David Vernier, Fran Poodry, and John Gastineau

Pivot Interactives is a customizable online-video environment that is a superb complement to hands-on experiments with Vernier sensors. Students are quickly engaged by these high-production-quality videos of hard-to-implement phenomena, which are a powerful supplement to hands-on experimentation. Explore the possibilities with us!

CW08: Expert TA: Some Instructors Now Think that Nothing Can Be Done About Cheating on Online Homework. We Disagree

Location: CC - Breakout 3
Date: Monday, July 24
Time: 12–1 p.m.
Sponsor: Expert TA

Leader: Jeremy A. Morton

The gap between students' homework grades and test scores is a concern we share with you. In a cross-institutional case study conducted in 2014-2015 involving 120 college physics classes, student access to online solutions was identified as the single biggest contributor. Cheating has long been an issue threatening the learning process, but it has never been easier for students to get access to answers. Most textbook solutions are readily available on answer sharing websites, but many instructors do not realize that students can submit any problem, and a solution will be posted in a matter of minutes. Even an instructor using his or her own problems is no longer immune. Since launching in 2009, Expert TA has focused exclusively on introductory physics. Reinforcing the problem solving process and including symbolic expressions has always been central to Expert TA's online homework system. In 2012 we began using Big-Data analytics to provide feedback specific to individual student mistakes. Now we are turning our attention to solving this challenging and the important problem of Academic Integrity. Join us for lunch and learn about the suite of Academic Integrity features and new strategies that we are implementing, designed to keep your students focused on the physics.

CW09: Optimized Content and Multi-Sensory Learning from Cengage with WebAssign

Location: CC - Breakout 2
Date: Tuesday, July 25
Time: 12–1 p.m.
Sponsor: Cengage

Leaders: Robert Teese, Kathleen Koenig, and Matt Kohlmyer

Learn about the new features and content optimizations to Cengage products in WebAssign that increase student engagement and reduce the likelihood of online cheating. Join us with speakers Dr. Robert Teese, Rochester Institute of Technology, and Dr. Kathleen Koenig, University of Cincinnati, to learn about student gains using Interactive Video Vignettes in WebAssign. Also joining is Cengage's Senior Instructional Content Developer, Matt Kohlmyer, who will give a demonstration of new content features and strategies that can help reduce the likelihood of cheating.

CW10: Perimeter Institute: Hands-On Wave-Particle Duality

Location: CC - Breakout 1
Date: Monday, July 24
Time: 3–4 p.m.
Sponsor: Perimeter Institute

Leaders: Glen Wagner, Damian Pope

The wave-particle duality is one of the deepest mysteries of quantum mechanics. Come explore a hands-on activity that introduces students to the concepts involved in the wave-particle duality. The Challenge of Quantum Reality resource was designed by educators in collaboration with Perimeter Institute researchers.

CW11: Perimeter Institute: Everyday Einstein: The Global Positioning System (GPS) and Relativity

Location: CC - Breakout 1
Date: Monday, July 24
Time: 1:30–2:30 p.m.
Sponsor: Perimeter Institute

Leaders: Glen Wagner, Damian Pope

The GPS is a technology used by millions of people. Surprisingly, it relies on Einstein's theory of relativity. Based on a resource by Perimeter Institute, this session shows how you can teach the link between the GPS & Einstein's greatest discovery using hands-on activities and easy-to-implement lesson plans.

CW12: Perimeter Institute: What's New in Physics?

Location: CC - Breakout 1
Date: Tuesday, July 25
Time: 1:30–2:30 p.m.
Sponsor: Perimeter Institute

Leaders: Glen Wagner, Damian Pope

Join us as we take a look at the coolest physics news items over the past year. This session will explore a variety of cutting-edge physics discoveries for teachers that are looking for current, real-world science connections in their classroom.

CW13: Vernier Solutions for Physics and Chromebooks

Location: CC - Breakout 3
Date: Tuesday, July 25
Time: 1–1:50 p.m.
Sponsor: Vernier

Leaders: David Vernier, Fran Poodry, and John Gastineau

Bring your Chromebook (or use one of ours) and learn how easy it is to connect sensors and collect and analyze data. Explore the free Graphical Analysis 4 app for data collection

AAPT Journals

Booth #31
One Physics Ellipse
College Park, MD 20740
301-209-3300
www.aapt.org

Drop by for information on how you can become part of the AAPT Publications program. Learn why you should submit articles for publication, consider becoming a reviewer, and make sure your physics department subscribes to *American Journal of Physics* and *The Physics Teacher*. It is rumored that it may be possible to catch up with journal editors and other members of the Publications Committee during your visit. If you are an online only member, you'll get a chance to see the print copies and reconsider your choice. If you aren't yet an AAPT member we will do our best to help you decide which option is best for you.

American Association of Physics Teachers

Booth #26
One Physics Ellipse
College Park, MD 20740
301-209-3300
www.aapt.org

Welcome to Cincinnati! Join us at the AAPT booth and spin the wheel for your chance to win awesome prizes. This year, try out our new interactive demos based on lesson plans created from *The Physics Teacher!* We will also have a large selection of educational resources available to meet the needs of everyone from students to faculty. Show us you've tweeted using the hashtag #AAPTSM17 or liked us on Facebook to be entered into a free raffle, and don't forget to pick up your raffle ticket for the Great Book Giveaway!

AAPT and Other Cincinnati Region Groups

Booth #4
2600 Clifton Ave.
Cincinnati, OH 45221
513-556-6000
www.uc.edu

Stop by the booth to connect with local Ohio and Kentucky section representatives to purchase a limited edition t-shirt, and engage in a Make-n-Take! Learn about several regional networks, their activities, and how you can get involved. Representatives will be present from groups including the Ohio and Kentucky Sections of AAPT. Contact information for other regional groups, including those in Indiana and West Virginia, will also be available. Ohio Section: osaapt.org; Southern Ohio Section of AAPT: sosaapt.weebly.com; Tri-State Physics Teachers: tspt.org; Kentucky Section: http://physics.wku.edu/kapt/

American Physical Society

Booth #7
2189 Flintstone Drive
One Physics Ellipse
College Park, MD 20740
301-209-3206
www.aps.org

The American Physical Society's Public Outreach Department aims to bring the excitement of physics to all. Stop by to grab our new retro poster series, your copy of Spectra's Quantum leap or hear more about www.physicscentral.com. We will also be demoing our new comic book app as well as SpectraSnapp for android.

Andrews University Physics Enterprises

Booth #34
4260 Administration Drive
HYH-212
Berrien Springs, MI 49104
269-471-3503
www.physicsenterprises.com

Physics Enterprises designs and manufactures high-quality teaching equipment for science classes. Our products are mainly represented by Vernier Software & Technology, PASCO scientific, VWR, American 3B Scientific, and TEL-Atomic. Visit our Booth to see our latest projects and share your ideas of what your class needs. More information at https://www.andrews.edu/services/physicsenterprises/.

Arbor Scientific

Booth #19
PO Box 2750
Ann Arbor, MI 48106
734-477-9370
www.arborsci.com

For 30 years, Arbor Scientific has worked with physics and physical science teachers to develop educational science supplies, science instruments, and physics lab equipment that make learning fun, engaging and relevant for students and teacher's alike. Stop by our Booth and try the most fascinating, dynamic, hands-on methods that demonstrate key concepts and principles of physics and chemistry. We find the cool stuff!

Carney, Sandoe, & Associates

Booth #5
44 Bromfield Street
8th Floor
Boston, MA 2108
617-542-0260
www.carneysandoe.com

At Carney, Sandoe & Associates, we do the hard work of finding the right candidates for you. We know that every school is not created equal: a stand-out candidate for one community might not be a good match for another. Our experience, passion, and diligence allow us to make the right match between a school and a candidate — and we've done so over 31,500 times since 1977

Cengage

Booth #33
303 Second St.
Ste 500 South
San Francisco, CA 94107
530-746-0446
www.cengage.com

Cengage believes in the power and joy of learning. We enrich the relationship between educators and students by advancing the way students learn. Visit our booth to learn about our digital solution WebAssign (including new Interactive Video Vignettes), new content, and personalized services. www.cengage.com/s/physics

Disney Youth Programs

Booth #30
P.O. Box 10111
Lake Buena Vista, FL 32830
407-566-2653
www.disney.com

Youth Education Series: Disney Youth Education Series offers educational field trip programs and academic journeys year-round. Participants find enrichment, inspiration, and pure fun as they see how principles they're learning in the classroom are making exciting things happen around the Disney Parks.

eScience Labs

Booth #36
1500 W. Hampden Ave.
Building 2
Sheridan, CO 80110
303-741-0614
www.esciencelabs.com

eScience Labs collaborates with over 350 higher education institutions to provide a traditional hands-on laboratory experience to students engaged in online learning.

Through a combination of hands-on science lab kits, virtual learning tools, and customized digital curriculum, eScience Labs helps colleges and universities expand and strengthen science comprehension.

Expert TA

Booth #22
624 South Boston Avenue
Tulsa, OK 74119
918-978-9695
www.theexpertta.com

The Expert TA is an online homework and tutorial system for introductory physics courses. Expert TA's proprietary math engine performs partial credit grading of the most complex problems. It analyzes the steps used to solve equations, identifies detailed mistakes and deducts the appropriate points. This method allows instructors to accurately evaluate the mastery of student knowledge and provides students with consistent grading and quality feedback on their work. Stop by Booth 22 for a demonstration.

IOP Publishing

Booth #37
Temple Circus, Temple Way
Bristol, UK BS1 6HG
www.ioppublishing.org
44-011 9301153

Physics Education is the international journal for everyone involved with the teaching of physics in schools and colleges. The articles reflect the needs and interests of secondary school teachers, teacher trainers and those involved with courses up to introductory undergraduate level. PED readers benefit from the experience and expertise of the journal's international editorial board of leading practitioners.

Klinger Educational Products Corp.

Booth #24
86 Glen Cove Road
Roslyn Heights, NY 11356
718-461-1822
www.KlingerEducational.com

This year KLINGER will be introducing new products that cover a wider range of topics and levels to teach physics. In addition to advanced physics teaching equipment we will also have a selection of items for the high school and middle schools. Demonstration of the LEYBOLD x-ray apparatus and tomography module will be conducted in our booth. Both now have a locking, storage drawer that fits directly under the main units as well as a HD upgrade for the goniometer, enabling a 10X higher resolution 0.01 deg., achieved through narrower apertures and software. X-rays are detected with an end-window counter or an energy detector. Additionally, we will be exhibiting our dependable Electron Diffraction and Deflection tubes and a Ne Franck-Hertz experiment. We look forward to seeing current and new members of the AAPT to say hello and catch up on events happening in the field of physics teaching.

Macmillan Learning

Booth #40
41 Madison Avenue
New York, NY 10010
800-446-8923
www.whfreeman.com/physics

Macmillan Learning strives to support and enhance the Physics and Astronomy teaching and learning experience. Come by Booth # 40 to learn more about how we are partnering with thought leaders in Physics and Physics education to change the landscape in Physics offerings, like iOLab (from Mats Selen and Tim Stelzer) and innovative books like the upcoming College Physics 2e by Roger Freedman Interact with FlipItPhysics and Sapling Learning to learn how to best engage students from pre-lecture animations to robust post-lecture assignments with targeted feedback and unparalleled service. Browse our catalog to learn more and to view physics and astronomy titles at www.macmillanlearning.com.

Merlan Scientific

Booth #16
234 Matheson Blvd.
Mississauga
Ontario, Canada
1800-387-2474
merlanusa.com

Merlan Scientific Booth #16 – Your source for Quality Optics/Physics teaching equipment. For over 45 years, Merlan Scientific has provided quality Science teaching resources. We are proud to introduce our premium Optics/Physics range. Great institutions such as CUNY endorse our Optics/Physics range, and we think you will be very impressed too. Much of our equipment are made in Europe and 'the accuracy and quality is unrivalled' (CUNY). Join us at Booth 16 to view some of our equipment including our new mecca table, thermal imager, wind tunnel and much more. We will be happy to answer any questions you have and we also have great giveaways and offers including a coupon giving you a huge 15% off your first order with Merlan USA. www.merlanusa.com; 1800-387-2474; info@merlanusa.com

Morgan and Claypool Publishers

Booth #15
1210 5th Ave. Suite 250
San Rafael, CA 94901
908-630-7188
www.morganclaypool.com

IOP Concise Physics (by Morgan & Claypool) publishes short texts in over 30 distinct areas of physics. These books provide researchers, teachers, and students with an introduction to key principles in multiple areas, a look back at historical events and people, and also delve into issues surrounding effective teaching methods.

OpenStax

Booths #17, 18
6100 Main Street
MS-375
Houston, TX 77005
713-348-5012
www.openstaxcollege.org

OpenStax is a nonprofit based at Rice University, and our mission is to improve access to education. Our free, peer-reviewed college textbooks have been used by nearly 700,000 students, and we're piloting adaptive, personalized learning technology that improves student learning. Through philanthropic partnerships, OpenStax is empowering students and instructors to succeed.

PASCO scientific

Booths #43, 42, 41
10101 Foothills Blvd.
Roseville, CA 95747
800-772-8700
www.pasco.com

PASCO technologies transform science education and student learning with award-winning wireless probeware, software, and curriculum, promoting science inquiry and 21st century readiness skills for the global marketplace. Today teachers and students worldwide use PASCO solutions for physics, biology, chemistry, earth and environmental sciences, as well as programming and robotics.

Pearson

Booth #20
221 River St.
Hoboken, NJ 7506
www.pearsonhighered.com

Every learning moment builds character, shapes dreams, guides futures, and strengthens communities. At Pearson, your learning gives us purpose. We are devoted to creating effective, accessible solutions that provide boundless opportunities for learners at every stage of the learning journey. For more information, visit www.pearsoned.com.

Perimeter Institute for Theoretical Physics

Booth #21
31 Caroline Street N.
Waterloo ONT, 0
Canada
519-569-7600
www.perimeterinstitute.ca

Perimeter Institute for Theoretical Physics is an independent, non-profit charity, research institute whose mission is to make breakthroughs in our understanding of our universe and the forces that govern it. Such breakthroughs drive advances across the sciences and the development of transformative new technologies. Located in Waterloo, Ontario, Canada, Perimeter also provides a wide array of research, training and educational outreach activities to nurture scientific talent and share the importance of discovery and innovation.

Quantum Design

Booth #29
10307 Pacific Center Ct.
San Diego, CA 92121
858-481-4400
www.qdusa.com

Quantum Design manufactures automated material characterization systems to further the research and education of physics, chemistry, and material science. These systems and associated curricula provide essential tools for engaging students and assisting teachers by providing hands-on instruction and experience using fundamental science principles. The VersaLab is a portable, cryogen-free cryocooler-based material characterization platform. With a temperature range of 50 – 400K, this 3 tesla platform is perfect for accomplishing many types of materials characterization in a limited space. A fully-automated system with a user-friendly interface, the VersaLab utilizes Quantum Design's PPMS platform measurement options.

Society of Physics Students

Booth #6
One Physics Ellipse
College Park, MD 20740
301-209-3008
www.spsnational.org

The Society of Physics Students (SPS), along with Sigma Pi Sigma, the national physics honor society, are chapter-based organizations housed within the American Institute of Physics. SPS strives to serve all undergraduate physics students and their mentors with a chapter in nearly every physics program in the country and several international chapters. Sigma Pi Sigma, with over 95,000 historical members, recognizes high achievement among outstanding students and physics professionals. SPS and Sigma Pi Sigma programs demonstrate a long-term commitment to service both within the physics community and throughout society as a whole through outreach and public engagement. Partnerships with AIP member societies introduce SPS student members to the professional culture of physics and convey the importance of participation in a professional society. SPS and Sigma Pi Sigma support scholarships, internships, research awards, physics project awards, outreach/service awards, and a job site for summer and permanent bachelor's level physics opportunities (jobs.spsnational.org).

Spectrum Techniques

Booth #23
106 Union Valley Road
Oak Ridge, TN 37830
865-482-9937
www.spectrumtechniques.com

Spectrum Techniques, the leading supplier of nuclear GM counting equipment, Exempt Quantity radioisotopes, and nuclear spectrometers is now showcasing a wifi enabled radiation counter with standard ethernet and USB.

TeachSpin

Booth #11
2495 Main St.
Suite 409
Buffalo, NY 14224
716-885-4701
www.teachspin.com

One visitor called it ‘a bounce house for physicists. We call it the Food Truck for the Physics Mind - a 44-foot trailer housing all our TeachSpin instruments up and running and ready to take data. We're parking it on the exhibit floor and inviting you in. Come see what could be coming your way!

Tel-Atomic

Booth #35
1223 Greenwood Avenue
Jackson, MI 49203
517-783-3039
www.telatomic.com

TEL-Atomic Inc. provides advanced undergraduate laboratory equipment to institutions around the globe. We offer equipment to explore atomic and nuclear physics, including the TEL-X-Ometer, an x-ray diffractometer which is used to determine the structure of simple crystals. We also offer an affordable Cavendish torsion balance for measuring the gravitational constant. Please visit our Booth to see these and other products.

Vernier Software and Technology

Booth #27,28
13979 SW Millikan Way
Beaverton, OR 97005
888-837-6437
www.vernier.com

Vernier Software & Technology is the leading worldwide innovator of real-time data-collection, graphing, and analysis tools for science education. Visit our booth to see our newly redesigned Dynamics Cart and Track System and demo our free Thermal Analysis app. Enter to win a FLIR ONE™ Thermal Camera for iOS!

Ward's Science, featuring CENCO Physics

Booth #38
P. O. Box 92912
Rochester, NY 14692
800-962-2660
www.wardsci.com

All you need to turn science lessons into science connections. Ward's Science is the exclusive distributor for all Cenco Physics products, connecting you to the same world-class quality and innovative physics apparatus and experiments you know from Cenco, plus a wide selection of additional physics related activities, kits, and supplies.

Shared Books

World Scientific Publishing

–The Committee of Japan Physics Olympiad, *Physics Olympiad - Basic to Advanced Exercises*

–Kenneth W. Ford, *Basic Physics – A Resource for Physics Teachers*

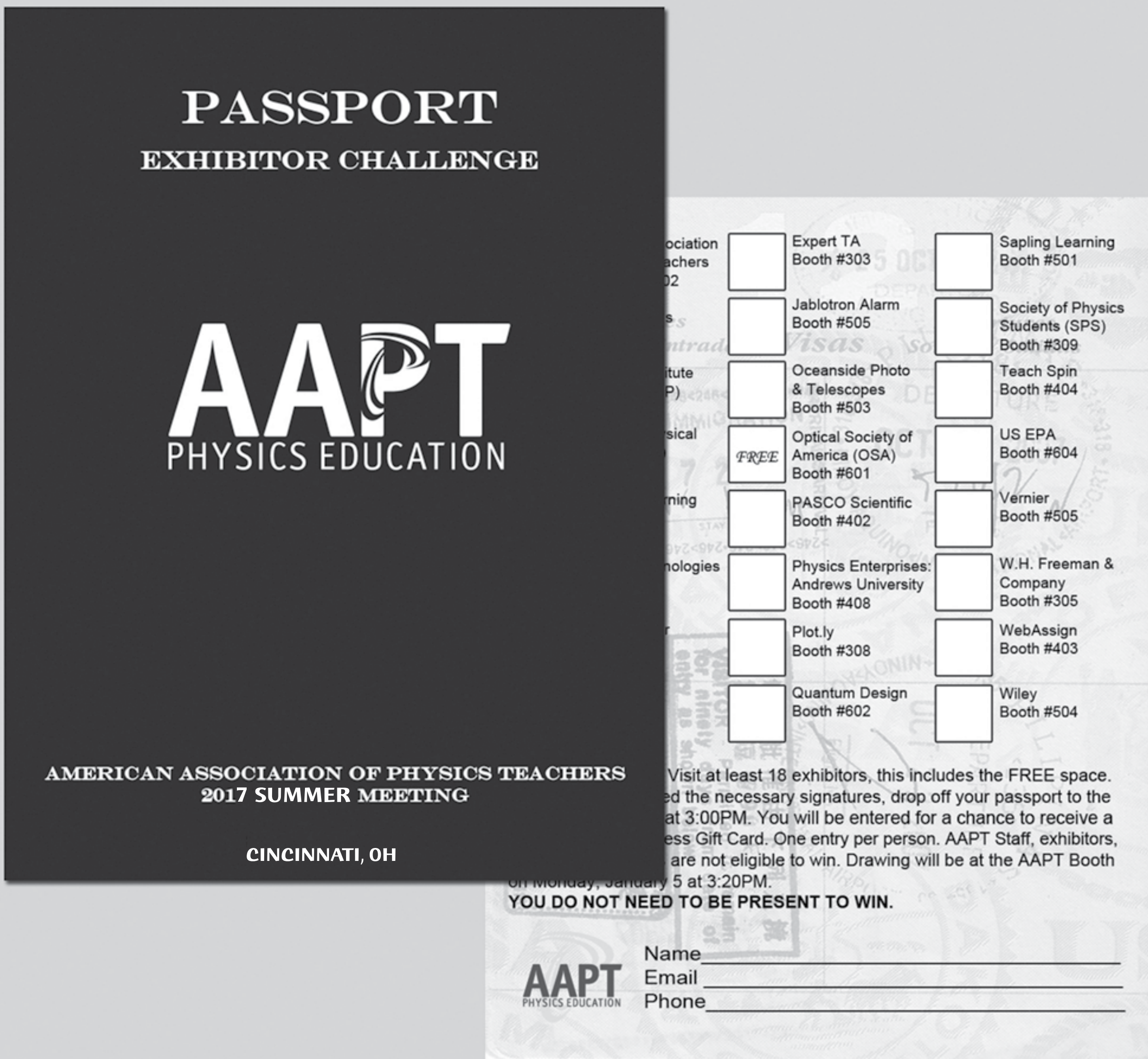
–Ernest M. Henley and J. Gregory Dash, *Physics around Us – How Things Work*

Netpub Education

–R. Lathrop, *A Little Bit of Physics – A Physics Workbook*

EXPLORE THE EXHIBIT HALL FOR YOUR CHANCE TO WIN A

$100 AMERICAN EXPRESS GIFT CARD



PICK UP YOUR PASSPORT TODAY!

Workshops – Saturday, July 22

Transportation between the Marriott and University of Cincinnati will be provided.

W02: Making High Speed Videos

Sponsor: Committee on Apparatus
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: 340 & 342 Braunstein

Paul Nord, Valparaiso University 1610 Campus Drive,Valparaiso, IN 46383; paul.nord@valpo.edu

Stephen Irons

Participants will explore the use of inexpensive high speed cameras for lecture demonstration and lab experiments. Several presenters will work to share experiences developing lab exercises. Cameras from GoPro and the new iPhones provide up to 240 frames per second. Nikon 1 cameras can take video at 1200 frames per second. A few cameras will be available for shared use. Participants are welcome to bring their own cameras. Topics discussed will include: lighting, mounting, geometry of the setup, optimizing camera settings, data transfer, correcting for fish-eye lens distortions, and the use of simple editing tools.

W03: Mathematical Modeling with Desmos

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: 312 Braunstein

Michael Lerner, 25100 Fairmount Boulevard, Beachwood, OH 44122; mlerner@beachwoodschools.org

Desmos is a seemingly simple online graphing calculator that hides a powerful tool for high school and introductory college physics classes. Originally designed for math teachers, Desmos is an easy way to graph functions, fit curves, and linearize data. We'll learn how to use these basic functions and then explore how Desmos can be a great first step to bring computational and graphical problem solving into physics classes. We'll also learn about creating independent and whole-group activities using Desmos' built-in classroom activity builder. Participants will have time and support to build their own activities. Participants are required to bring a laptop computer with a current version of Firefox, Chrome or Safari installed.

W04: iMobile Physics and iPhysics Classroom

Sponsor: Committee on International Physics Education
Co-sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: 325 Braunstein:

André Bresges, University of Kaiserslautern, Department of Physics/ Physics Education Research Group, Erwin-Schrödinger-Str., Building 46 (Room 525), 67663 Kaiserslautern, Germany; andre.bresges@uni-koeln.de

Pascal Klein, Colleen Countryman, Michael Thees

Smartphones and tablets can be used as experimental tools especially in physics classrooms. This is possible because today's smartphones and tablets are equipped with many sensors which can be used to perform quantitative and qualitative experiments. We will describe how these mobile devices could be used as mobile Pocket-Labs throughout various topics by students in high school and introductory physics courses. Participants will learn and practice how to use these mobile devices as experimental tools in the topics mechanics (video motion analysis and others) and acoustics, using our provided devices or their own ones.

W05: Make and Take Low Cost Spectrograph for Physics Labs

Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Apparatus
Time: 8 a.m.–12 p.m. Saturday
Member Price: $85 **Non-Member Price:** $110
Location: 300 Geology-Physics

Timothy Grove, IPFW Physics Department, 2101 E. Coliseum Blvd. Fort Wayne, IN 46805; grovet@ipfw.edu

Spectrographs (a device used to take pictures of spectra) are typically expensive and fragile. Our shoebox spectrograph is quite different. It is made of scrap corrugated cardboard, a DVD fragment, duct tape, school glue, and a webcam. Despite the inexpensive parts (~ $22/unit), the shoebox spectrograph can be remarkably accurate (~ 1.5nm accuracy for a well-constructed device and they can resolve the Hg 576.96nm line from the 579.07nm line). Furthermore, there are numerous low cost experiments (assuming available computers) involving the spectral features of light that can be explored using this spectrograph. These experiments include, but are not limited to, observation of atomic spectra, observation of the Fraunhofer lines, reflection of white light off colored objects including dandelion flower reflection spectroscopy, transmission of white light through dye tinted water, and even laser induced fluorescence of Play Doh. Attendees will learn how to construct their own spectrographs out of pre-cut cardboard and then use them. Then a representative experiment will be done (laser induced fluorescence of Play Doh; the purpose of this experiment is to help students understand the difference between fluorescence and reflection).

W06: Modern Physics Labs on a Budget Using LEDs and Mixed Signal Processors

Sponsor: Committee on Laboratories
Co-sponsor: Committee on Apparatus
Time: 8 a.m.–12 p.m. Saturday
Member Price: $85 **Non-Member Price:** $110
Location: 303 Geology-Physics

Mark Masters, IPFW Department of Physics, 2101 Coliseum Blvd. E, Fort Wayne, IN 46805; masters@ipfw.edu

Jacob Millspaw

Participants will build (and take with them) several pieces of equipment to perform some modern physics investigations using LED's. First, participants will use a microcontroller to measure the I-V curve of several LED's and determine the Boltzmann constant. Second, we will use LED's as very inefficient single photon avalanche photodiodes and do several counting and coincidence investigations. In the process the participants will learn about how to use the mixed signal microcontrollers for other investigations as well.

W07: "Can We Have a Group Test?" Designing Collaborative, Active, Alternative Assessments for Physics Classes

Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on Teacher Preparation
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: 348 Braunstein

Kelly O'Shea, LREI 40 Charlton Street, New York, NY 10014; kellyoshea@gmail.com

Danny Doucette

The Next Generation Science Standards require that students construct explanations and design solutions using scientific practices. Lab practicums are an engaging and effective way for students to demonstrate their understanding. At the same time, students often learn and work in groups, and scientists also work in teams. How can we design assessments that challenge students to use their practical skills while also reflecting the social nature of scientific understanding? In this workshop, participants will experience a collaborative practical exam, learn about different approaches to group and practical assessments, think through how to apply these assessments in their own classrooms, and have an opportunity to design and try out a practical assessment of their own. We hope that this workshop will be interesting to a wide audience, and we hope it will be especially useful for high school physics teachers.

W08: Introductory Labs for Electricity and Magnetism

Sponsor: Committee on Laboratories
Time: 8 a.m.–12 p.m. Saturday
Member Price: $72 **Non-Member Price:** $97
Location: 346 Braunstein

Kenneth Lonnquist, CSU Physics Kenn 1875 Campus Delivery, Fort Collins, CO 80523-1875; kenneth.lonnquist@rams.colostate.edu

Whether your lab curriculum is ripe for an overhaul, well-established, or you are simply looking for exciting and innovative activities for the classroom, this workshop will provide new ideas to bring home to your institution. Presenters from colleges and universities across the United States will each demonstrate their approach to a favorite introductory lab exercise. This year's workshop will focus on labs for Electricity and Magnetism. Attendees will have the opportunity to work with each apparatus. Documentation will be provided for each experiment, with lab manuals, sample data, equipment lists, and construction or purchase information. This workshop is appropriate primarily for college and university instructional laboratory developers, but all instructors are welcome.

W12: Physics Activities for the Life Sciences (PALS)

Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Laboratories
Time: 8 a.m.–5 p.m. Saturday
Member Price: $85 **Non-Member Price:** $110
Location: 316 Braunstein

Duane Deardorff, Campus Box 3255, University of North Carolina, Chapel Hill, NC 27599; duane.deardorff@unc.edu

Alice Churukian, Colin Wallace

Physics instructors are increasingly being asked to reform their teaching practices and use evidence-based instructional strategies to actively and intellectually engage their students. In this workshop, participants will gain firsthand experience implementing multiple collaborative learning activities that have been specifically designed for use in introductory physics for life science (IPLS) courses. Examples will include content from mechanics, electricity, magnetism, and optics, with each activity grounded in real-world applications to biological phenomena and/or medical practices. Participants will also gain a better understanding of student difficulties in IPLS-focused topics and be introduced to teaching methods aimed at addressing such issues.

W13: Learn Physics While Practicing Science: Introduction to ISLE*

Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Two-Year Colleges
Time: 8 a.m.–5 p.m. Saturday
Member Price: $95 **Non-Member Price:** $120
Location: 426 Braunstein

David Brookes, 400 W. First St., Chico, CA 95929-0202; dbrookes@csuchico.edu

Robert Zisk, Yuhfen Lin

Participants will learn how to modify introductory physics courses to help students acquire a good conceptual foundation, apply this knowledge in problem solving, and engage them in science practices. The framework for these modifications is Investigative Science Learning Environment (ISLE). We provide tested curriculum materials including: (a) The College Physics Textbook by Etkina, Gentile and Van Heuvelen, the Physics Active Learning Guide and the Instructor Guide; (b) a website with over 200 videotaped experiments and questions for use in the classroom, laboratories, and homework; (c) a set of innovative labs in which students design their own experiments, and (d) newly developed curriculum materials that use LEDs to help students learn physics. During the workshop the participants will learn how to use the materials in college and high school physics courses to help their students learn physics by practicing it. We will focus on the connections of our materials with the NGSS and revised AP curriculum, specifically on the interplay of science practices and crosscutting concepts. *Please bring your own laptop to the workshop if you own one. Make sure it has Quicktime installed. If you do not own a computer, you will be paired with somebody who does.

W14: The Perplexed Physicists' Primer on Teaching Astronomy

Sponsor: Committee on Space Science and Astronomy
Time: 8 a.m.–5 p.m. Saturday
Member Price: $85 **Non-Member Price:** $110
Location: 201 Braunstein

Tim Slater, University of Wyoming, 1000 E University, Laramie, WY 82071; timslaterwyo@gmail.com

Stephanie J. Slater, Windsor Morgan, Chris Palma

Although physicists are highly qualified academically to teach astronomy, few have had significant experience in doing astronomy either professionally or as a hobby. Moreover, because most students electing to enroll in astronomy are self-proclaimed non-science students, the nature of students' motivation, background, and mathematical sophistication differs considerably from students who typically take physics. Taken together, teaching the astronomy course offers new teaching challenges that are often unfamiliar to even the most talented physics professors. This full day teaching strategies workshop provides a step-by-step success plan for physicists who have been assigned to teach astronomy. Topics include designing an effective syllabus for non-science students and future teachers, appropriate mathematical and quantitative reasoning tasks, interactive lecturing strategies designed to captivate the widest diversity of students, how to best to utilize textbooks, how to use telescopes, where to find the best astronomy pictures, and efficient testing and grading strategies for busy faculty. Classroom-ready materials will be distributed to all participants. Attendees are encouraged to bring their laptops, sample syllabi, textbooks, and exams to discuss with workshop leaders.

W17: Low-Cost Open-Source Laboratory Instruments

Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Laboratories
Time: 1–5 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: 312 Braunstein

Brian D'Urso, 100 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15260; dursobr@pitt.edu

Scientific equipment for research can be expensive and complex, while equipment specifically designed for instructional laboratories is often too limited. Neither typically allows students to understand or modify the inner workings of the instruments. In this workshop, we will show you how to make several common laboratory instruments using inexpensive and open hardware and software. Specifically, we will show how to use an Arduino microcontroller board and a personal computer running Python to make an oscilloscope, waveform generator, spectrum analyzer, and network analyzer. With a Raspberry Pi and touchscreen as the computer, these can combined into a standalone, touchscreen-controlled instrument. We will show how you can customize the instruments and how to create a completely new instrument using the same tools. This workshop is most appropriate for those teaching intermediate and advanced instructional physics laboratories, although it may also be valuable for those looking for low-cost instruments for introductory labs.

W18: Physics of Toys

Sponsor: Committee on Science Education for the Public
Co-sponsor: Committee on Physics in Pre-High School Education
Time: 1–5 p.m. Saturday
Member Price: $61 **Non-Member Price: $86**
Location: 300 Braunstein

Beverly Taylor, 6490 Niderdale Way, Middletown, OH 45042; taylorba@miamioh.edu

This hands-on workshop is designed for teachers at all levels in search of fun physics demonstrations and lab experiments using ordinary children's toys. The exploration of common toys aids deep learning by emphasizing concepts and connections before formal definitions and mathematics. It also connects the science to the familiar world outside of the classroom and gets students writing and talking about physics ideas. Investigating what toys do and how they do it can be a challenging application of undergraduate physics from the introductory course up through senior mechanics. In fact, I have found that toys can be utilized at all grade levels from kindergarten through college by varying the sophistication of the analysis. These same toys can be used for informal presentations to public groups of all ages. More than 60 toys will be demonstrated, and the physical principles related to these toys will be discussed. A wide variety of physics topics will be addressed including forces, energy, magnetism, sound and light. Because the meeting is so close to home for me, I will be able to bring a wider variety of toys than normal. You will have the opportunity to participate in both qualitative and quantitative investigations using toys.

W19: Computational Modeling with GlowScript and VPython

Sponsor: Committee on Physics in Two-Year Colleges
Co-Sponsor: Committee on Space Science and Astronomy
Time: 1–5 p.m. Saturday
Member Price: $60 **Non-Member Price: $85**
Location: 300 Geology-Physics

Tom O'Kuma, Lee College Physics, P. O. Box 818 Baytown, TX 77522; tokuma@lee.edu

Dwain Desbien, David Weaver

Over the last few years, we have implemented a number of different computational modeling activities in our introductory physics courses. These activities use either VPtyhon (http://vpython.org) or Glowscript (http://glowscript.org). Several of these activities have been developed in conjunction with a series of workshops done as part of the ATE Physics Workshop Project. Participants will work activities used in a typical two-semester introductory physics course ranging from conceptual level to calculus-based level. In this workshop, participants will work with some of these activities and develop their own. Participants are asked to bring their own laptops with VPython already downloaded on your laptop and a web browser to access the internet.

W20: Examining the Relationships among Intuition, Reasoning, and Conceptual Understanding in Physics

Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Saturday
Member Price: $60 **Non-Member Price: $85**
Location: 340 & 342 Braunstein

Andrew Boudreaux, Department of Physics, Western Washington University, 516 High St Bellingham, WA 98225-9164; andrew.boudreaux@wwu.edu

Paula Heron, Mila Kryjevskaia, Beth Lindsey, Mackenzie Stetzer

Physics instructors commonly expect their students to consciously and systematically draw on their formal physics knowledge to construct chains of reasoning that start from established principles and lead to well-justified predictions. If exam performance does not seem to match such thinking patterns, it is often assumed that students either do not possess the requisite conceptual understanding or lack the reasoning ability needed to chain the appropriate ideas together. An emerging body of research rooted in cognitive science provides a somewhat different explanation: students may "abandon" formal reasoning in favor of ideas that are (perhaps) more intuitively appealing at that moment. Although relatively little is known about the complex relationships among intuition, reasoning, and conceptual understanding in physics contexts, insight into these relationships is important for both researchers and instructors. In this workshop, participants will explore these relationships by examining student responses to a variety of assessment tasks. The focus will be on collaborative analysis and interpretation of such student data, and discussion of the implications for instruction.

W21: An Example of Tutorials for Upper-division Physics Courses: Quantum Mechanics

Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Time: 1–5 p.m. Saturday
Member Price: $65 **Non-Member Price: $90**
Location: 346 & 348 Braunstein

Peter S. Shaffer, University of Washington, Department of Physics, Box 351560, Seattle, WA 98195-1560; shafferp@uw.edu

Paul J. Emigh, Gina Passante

Tutorials in Physics: Quantum Mechanics is a set of instructional materials intended to supplement traditional lecture instruction in quantum mechanics courses, particularly courses targeted at upper-division physics majors. The tutorials address conceptual, mathematical, and reasoning difficulties that research suggests can impede student learning of key ideas in quantum mechanics. The workshop will provide hands-on experience with the instructional materials and results from assessments of student learning. Topics of discussion will include ways in which the tutorials can be implemented in a wide variety of different course structures; possible challenges to the use of interactive curriculum in upper-division courses; and differences between tutorials for introductory and more-advanced levels.

W22: PIRA Lecture Demonstrations I & II Condensed: Selections from the PIRA 200

Sponsor: Committee on Apparatus
Time: 1–5 p.m. Saturday
Member Price: $95 **Non-Member Price: $120**
Location: 301 Braunstein

Dale Stille and Sam Sampere, Rm 58 Van Allen Hall, Dept. of Physics and Astronomy, Univ. of Iowa, Iowa City, IA 52242; dale-stille@uiowa.edu and smsamper@syr.edu

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

W23: An Introduction to Race, Ethnicity, and Equity in Physics Education

Sponsor: Committee on Diversity in Physics
Co-sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Saturday
Member Price: $65 Non-Member Price: $90
Location: 324 Braunstein

Vashti Sawtelle, 567 Wilson Rd., East Lansing, MI 48824; vashti.sawtelle@gmail.com

Angela Little, Chandra Turpen

This workshop focuses on race, ethnicity and equity in the context of physics education. We especially encourage those that may feel novice in talking about race and ethnicity to attend, but welcome everyone who is interested in exploring this area as well. We will support participants to examine educational spaces through the lenses of race and ethnicity. We will also consider how race and ethnicity play a role in systemic issues affecting physics education more broadly. Topics to be explored will be guided by participant input and may include, but are not limited to: identity, culture, privilege, microaggressions, implicit bias, and colorblind rhetoric. We will engage in group conversations, self-reflection, and explore possibilities for action within our own institutional contexts.

W24: Student Activities from the IceCube Neutrino Experiment

Sponsor: Committee on Modern Physics
Co-sponsor: Committee on Space Science and Astronomy
Time: 1–5 p.m. Saturday
Member Price: $60 Non-Member Price: $85
Location: 303 Geology-Physics

Silvia Bravo Gallart, Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin—Madison. 222 West Washington Ave, Suite 500, Madison, WI 53703 ; silvia.bravo@icecube.wisc.edu

Jim Madsen

In this workshop, educators and researchers from the IceCube Neutrino Observatory will demonstrate a series of activities for juniors and seniors in high school physics courses. These activities introduce advanced concepts in physics, such as the Standard Model of Particles and Interactions, and invite students to perform guided research activities using IceCube data. IceCube is a cubic-kilometer telescope located deep in the ice at the South Pole that uses neutrinos, instead of light, to study the extreme universe. In 2014, IceCube launched a research-based educational program for high school students called the IceCube MasterClasses. The activities presented in this workshop were developed for these masterclasses and have been tested with more than 500 high school students in the US and Europe. The IceCube masterclasses are inspired by a similar program coordinated in the US by QuarkNet. The workshop will highlight two activities: - A role-based game to introduce the Standard Model of Particles and Interactions– A guided research activity to replicate the discovery of astrophysical neutrinos by IceCube.

Workshops – Sunday, July 23

W27: High Altitude Ballooning

Sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Sunday
Member Price: $75 Non-Member Price: $100
Location: 340 Braunstein

Erick Agrimson, 2004 Randolph Ave.; epagrimson@stkate.edu

Kaye Smith, James Flaten

Ever dream of doing science in space? High-altitude weather balloons can lift science experiments into the stratosphere, providing relatively low-cost and uncomplicated access to a space-like environment (and view)! Sending experiments to "near-space" is an unforgettable experience which can address a wide range science and engineering standards. This workshop will provide an introduction for those who wish to explore this exciting type of platform in their classroom. We will share ideas for college as well as pre-college projects and undergraduate collaborative research that can make use of this hands on experimental platform.

W28: Physics Invention Tasks: Developing Mathematical Creativity as a Scientific Practice

Sponsor: Committee on Research in Physics Education
Co-sponsor: Committee on Physics in Two-Year Colleges
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 351 Braunstein

Suzanne Brahmia; brahmia@physics.rutgers.edu

Stephen Kanim, Andrew Boudreaux

This workshop introduces PITs (Physics Invention Tasks[1]), curricular activities designed to foster mathematical creativity in the context of physical quantities and relationships. Affective measures show that traditional physics instruction results in students viewing physics as formulaic (Adams et al. 2006), which may contribute to the lack of diverse interest in calculus-based physics courses (Ross & Otero, 2013). Important goals of PITs include developing expectations that physics should make sense, and strengthening beliefs that naïve views and mathematical sensemaking facilitate learning physics. Research in mathematics education has shown that invention tasks help students use math creatively while priming them for subsequent formal instruction (Schwartz et al., 2011). PITs support the construction of quantitative physics concepts and relationships while contributing to a well-defined set of physics course norms in which struggle is communal, there are no dumb ideas, and creativity is valued. These norms align well with authentic science practices and the NGSS practices, but contrast starkly with a stereotypical physics course in which there is little motivation for its algebraic reasoning. In this workshop participants will be introduced to the many PITs that are developed and validated1 and will get started on developing their own tasks.

1. https://arxiv.org/pdf/1602.02033.pdf

W30: Fun and Engaging Labs

Sponsor: Committee on Teacher Preparation
Co-Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 348 & 346 Braunstein

Wendy Adams, University of Northern Colorado, 501 20th Street, Greeley, CO 80639; wendy.adams@unco.edu

Duane Merrell

In this workshop we will share many labs that are suitable for both high school and introductory college physics. The labs are challenging but not too difficult and, leave plenty of room for creativity! We have found success by limiting the goals for the labs to: 1. Fun and engaging, 2. Built in student choice, 3. Related to this week's material. The labs are effective at engaging the students in problem solving and conceptual understanding. Merrell used this type of lab as a high school teacher and physics quickly became one of the most popular classes in the school. Adams, inspired by Merrell, has found that her college students no longer rush to leave, and in some cases stay to see how other groups do even after they've turned in their lab write up for the day! This workshop will allow you to try out these labs for yourself.

W32: What Every Physics Teacher Should Know About Cognitive Research

Sponsor: Committee on International Physics Education

Co-sponsor: Committee on Research in Physics Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 316 Braunstein

Chandralekha Singh, 3941 Ohara St.; clsingh@pitt.edu

In the past few decades, cognitive research has made significant progress in understanding how people learn. The understanding of cognition that has emerged from this research can be particularly useful for physics instruction. We will discuss and explore, in a language accessible to everybody, how the main findings of cognitive research can be applied to physics teaching, learning and assessment.

W33: Interdisciplinary Instruction in Biological Physics

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 303 & 304 Geology-Physics

Philip Nelson, Physics/Astron, Univ. of Pennsylvania, 209 South 33d St., Philadephia PA 19104; nelson@physics.upenn.edu

Physics departments must constantly develop up-to-date courses that can attract both majors and non-majors. One often-neglected area of opportunity is at the intermediate level. Specifically, students from Bioengineering, Materials, Chemistry, Chem.E., Biochemistry, Biophysics, and even Physics, from second-year undergraduates up, are keenly interested in biophysical topics. There is also a growing cohort of premedical students in these majors who have enough interest and aptitude in quantitative work to go beyond standard first year courses. The session will invite instructors with skills at reaching this group of students. Many faculty find such interdisciplinary instruction scary, at first, so there is much to discuss. The session will include: * Science tutorials, especially on recent revolutions in light imaging (superresolution, two-photon, etc), stochastic simulation, dynamical systems, visual neuroscience. * Discussion of project-based learning, including pairing students across disciplines as partners. * Discussion of collaborative tasks, especially getting students up and running with computer programming very fast, in a course not explicitly dedicated to computation. * Discussion of inexpensive in-class demos. * Strategies for meaningful assessment in interdisciplinary classes of this sort. Participants should bring a laptop computer to the session. Limited funds are available to partially offset participants' travel costs..

W34: Fun, Engaging, and Effective Labs and Demos in Electricity, Magnetism and Optics with Clickers, Video Analysis, and Computer-Based Tools

Sponsor: Committee Research in Physics Education
Co-Sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Sunday
Member Price: $75 Non-Member Price: $100
Location: 350 Braunstein

David Sokoloff, 1430 E 43rd Avenue, Eugene, OR 97405; sokoloff@uoregon.edu

Ronald Thornton, Priscilla Laws

RealTime Physics and Interactive Lecture Demonstrations have been available for over 15 years—so what's new? Participants in this workshop will have hands-on experience with some of the activities in RTP and ILD using clickers, video analysis and computer-based tools to teach electricity, magnetism and optics. These active learning approaches for lectures, labs, and recitations (tutorials) are fun, engaging and validated by physics education research (PER). Research results demonstrating the effectiveness of these curricula will be presented. The following will be distributed: Modules from the Third Edition of RTP, the ILD book, and the Physics with Video Analysis book and CD.

W35: Explore Your Assessment Data with the PhysPort Data Explorer

Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Diversity in Physics
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 300 Geology-Physics

Sam McKagan; sam.mckagan@gmail.com

Adrian Madsen, Eleanor Sayre

Do you have piles of data from concept inventories such as the FCI, FMCE, BEMA, CSEM, CLASS, or MPEX, that you haven't gotten around to analyzing yet? Are you curious what kinds of patterns are in your data? Would you like to compare your data to national averages? In this interactive workshop, you will upload your students' assessment and demographic data to the PhysPort Data Explorer (www.physport.org/dataexplorer), get instant analysis and visualization, explore patterns, and discuss these patterns and their implications with other participants.

W37: Periscope: Looking Into Learning in Best-Practices Physics Classrooms

Sponsor: Committee on Professional Concerns
Co-Sponsor: Committee on Women in Physics
Time: 1–5 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 426 Braunstein

Rachel Scherr, Senior Research Scientist, Seattle Pacific University, 3307 Third Ave. West; rescherr@gmail.com

Tali Hairston

Periscope is a set of lessons to support learning assistants, teaching assistants, and faculty in learning to notice and interpret classroom events the way an accomplished teacher does. Periscope lessons are centered on video episodes from a variety of best-practices university physics classrooms. By observing, discussing, and reflecting on teaching situations similar to their own, instructors practice applying lessons learned about teaching to actual teaching situations and develop their pedagogical content knowledge. They also and get a view of other institutions' transformed courses, which can support and expand the participants' vision of their own instructional improvement and support the transfer of course developments among faculty.

W38: Intermediate and Advanced Laboratories

Sponsor: Committee on Laboratories
Time: 1–5 p.m. Sunday
Member Price: $85 Non-Member Price: $110
Location: 339 Braunstein

Jeremiah Willams, Physics Department, Wittenberg University, PO Box 720, Springfield, OH 45504 ; jwilliams@wittenberg.edu

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

W39: Making Videos as Projects

Sponsor: Committee on Teacher Preparation
Co-sponsor: Committee on Educational Technologies
Time: 1–5 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 324 Braunstein

Dan MacIsaac, 1300 Elmwood Ave., 14222 Buffalo USA; danmacisaac@gmail.com

André Bresges, Florian Genz, David Abbott, Kathleen Falconer, Brad Gearhart, Joey Heimburger, and Andrew Roberts

Participants will learn how to make short physics video vignettes for learning purposes using modern tablets with low cost applets. Participants will view examples, learn and practice how to plan, storyboard, shoot, simply animate, edit, caption and voiceover videos using tablets. Constructive critiques and guidance will be provided, as well as advice on how to incorporate student video projects into physics classes. We encourage you to come to the workshop prepared with a physics topic of interest to you, and a tablet. Draft videos and storyboards are also welcome—the more you do in advance the more you can take away from the session. A limited number of loaner iPad tablets will be made available to participants without a device. This project is supported by the NSF, SUNY Buffalo State and the University of Cologne.

W40: Don't Lecture Me: Tutorial-based Curricula for Teaching Advanced Placement Physics

Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $65 Non-Member Price: $90
Location: 351 Braunstein

James Clarke, James Clarke Punahou School, 1601 Punahou St., Honolulu, HI 96822; jgclarke@punahou.edu

Michael Gearen, Peter Shaffer, Paula Heron

"Tutorials in Introductory Physics", by the Physics Education Group (PEG) at the University of Washington, has influenced physics curriculum development for decades, mostly at the college level. Based on "Tutorials", comprehensive tutorial-based curricula have been developed at Punahou School in Honolulu for each of the four Advanced Placement Physics courses, AP Physics 1 and 2, AP Physics C Mechanics and E&M. For several years, these inquiry-based tutorials have completely replaced the lecture portion of the courses at Punahou with demonstrably positive results. Workshop participants will experience a hands-on/minds-on introduction to tutorial instruction, playing the roles of students and tutorial instructors, and reflecting on lessons learned with the workshop presenters.

W42: Using Jupyter Notebook to Teach Physics with Computation

Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Educational Technologies
Time: 1–5 p.m. Sunday
Member Price: $65 Non-Member Price: $90
Location: 300 Geology-Physics

Aaron Titus, Department of Physics, High Point University, One University Parkway, High Point, NC 27268 ; hpuphysics@gmail.com

Ruth Chabay, Bruce Sherwood

Jupyter Notebook (formerly iPython Notebook) is a web application (front-end) to create and share documents that contain live code, visualizations, and marked-up text and equations. Teachers can write tutorials, and students can write professional, interactive reports. Accessible to students and scalable to professionals, Jupyter Notebook is ideal for both undergraduate research and for teaching computational modeling, data visualization, collaborative computing, and reporting. Furthermore, the latest version of VPython runs in Jupyter Notebook. In this workshop, participants will receive a set of Jupyter notebooks that demonstrate various features and will write their first notebooks, including Jupyter VPython.

W43: Developing the Next Generation of Physics Assessments

Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Time: 1–5 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 201 Braunstein

James T. Laverty, 213 Cardwell Hall, 1228 N. 17th St., Manhattan, KS 66502 ; laverty@phys.ksu.edu

Marcos D. Caballero

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

W44: Integrating Computation into Undergraduate Physics

Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Physics in Undergraduate Education
Time: 1–5 p.m. Sunday
Member Price: $20 Non-Member Price: $45
Location: 346 & 348 Braunstein

Larry Engelhardt, PO Box 100547, Florence, SC 29506; lengelhardt@fmarion.edu

Marie Lopez del Puerto, Kelly Roos, Danny Caballero, Norman Chonacky

In this workshop we will discuss the importance of integrating computation into the physics curriculum and will guide participants in discussing and planning how they would integrate computation into their courses. The PICUP partnership has developed materials for a variety of physics courses in a variety of platforms including Python/VPython, C/C++, Fortran, MATLAB/Octave, Java, and Mathematica. Participants will receive information on the computational materials that have been developed, will discuss ways to tailor the materials to their own classes, and will learn about opportunities that are available to receive additional support through the PICUP partnership. PLEASE BRING A LAPTOP COMPUTER WITH THE PLATFORM OF YOUR CHOICE INSTALLED.

This workshop is funded by the National Science Foundation under DUE IUSE grants 1524128, 1524493, 1524963, 1525062, and 1525525.

W45: Demo Kit in a Box: Electrostatics

Sponsor: Committee on Science Education for the Public
Co-Sponsor: Committee on Apparatus
Time: 1–5 p.m. Sunday
Member Price: $60 Non-Member Price: $85
Location: 312 Braunstein

Steve Lindaas, Department of Physics and Astronomy, MN State University Moorhead, 1104 7th Avenue South, Moorhead, MN 56563; lindaas@mnstate.edu

Adam Beehler

Reduced Cost! Participants will leave with lots equipment, supplies and knowledge to do demos! Are you looking for easy ways to infuse inquiry into your classroom? Don't have a demo manager? We will help you establish having several small demos conveniently packed into one box, ready for the classroom at any moment. You may bring your box to your class and use the demos to highlight lecture points, or use them when a student asks a question. Use a "Just-In-Time" teaching approach but with a demo twist! We will show you how to pack small demo kit boxes that pack a large instructional punch. The demo focus this summer is electrostatics (toys are likely to be involved). The cost of the equipment and supplies is being funded by a generous grant from the AAPT Fredrick and Florence M. Bauder Endowment Fund.

For more information visit us on line at Demo Kit in a Box (http://web.mnstate.edu/lindaas/AAPT/index.html)

W46: Strategies to Help all Women Succeed in Physics Related Professions

Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Women in Physics
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price: $85**
Location: 316 Braunstein

Chandralekha Singh, 3941 Ohara St., University of Pittsburgh, Pittsburgh PA 15260; clsingh@pitt.edu

Accumulating research on problem solving in physics clearly indicates that traditional, end-of-chapter exercises in physics texts are not useful and may actually hinder students' learning of important physics concepts. The research also raises questions about the efficacy of such tasks for helping students develop "problem solving skills." In light of these results the question is: What alternative tasks can we use to help students develop problem solving skills and a conceptual understanding? This workshop will review the research and then provide examples of several alternative tasks and their use. Participants will also get practice writing alternative problems in a variety of formats for use in their own classrooms.

T01: Designing and Running Your Own Physics Camp

Sponsor: Committee on Physics in Pre-High School Education
Co-sponsor: Committee on Science Education for the Public
Time: 8–11 a.m. Sunday
Member Price: $60 **Non-Member Price: $85**
Location: Marriott - Covington Ballroom I

Pati Sievert, STEM Outreach, Lowden 307 Northern Illinois University DeKalb, IL 60115

Paul Nord, Valparaiso University

Many physics enthusiasts have a cool hands-on experience to look back on as inspiration for investigating nature through physics. Running a physics camp program or offering physics sessions through other camps is one way to inspire children and teens to explore physics. Pati Sievert and Paul Nord have each started multiple successful camp programs at their respective universities, but the same planning process applies to high school teachers. In this tutorial these two experienced physics camp organizers will share insights and help you work through the decision making and planning processes for your future camp. As a group, we will discuss the pros and cons of developing an entirely new program or tagging on to another program. We will also consider these questions: What age range(s)? Single gender or co-ed? How do you choose positively challenging experiments? Why would you choose a residential camp or a day camp? By the end of the tutorial you will have thought through locations, payment methods, and employment issues, as well as programming and marketing your program. Maximize your experience by coming prepared to share why you want to launch a camp.

U.S. Physics Team Academic Director Wanted

The American Association of Physics Teachers (AAPT) seeks applications for the position of U.S. Physics Team Academic Director. We are seeking someone who will lead the preparation of 20 to 24 gifted U.S. high school students for the International Physics Olympiad (IPhO). The director has the opportunity to lead a program with a remarkable history, as well as adapt the program in response to national imperatives for fostering physics talent, particularly within historically underrepresented populations. The director provides general oversight of the U.S. competition including recruiting and training team coaches, preparing and grading exams, training of the U.S. Physics Team during training camp, and traveling with the Team to the IPhO.

Qualifications for the Physics Team Academic Director:

- A background in physics with classroom and laboratory experience, demonstrated involvement with students in special projects or activities, and an appreciation of the physics culture of problem-solving and experimental investigation.
- A record of managing complex tasks and improving processes through innovation.
- Ability to carry out responsibilities throughout the year.
- Be available to oversee the training camp held at the University of Maryland, usually during late May and early June, and lead the Team to the IPhO in July.
- Ability to work as part of a team to support the program as well as develop relationships with teachers, parents, and corporate sponsors.

To apply, please provide the following:

- A statement of interest addressing how you meet the qualifications
- A current c.v. that includes the names and contact information for two references (preferably AAPT members)

Send materials to eo@aapt.org with "Application for U.S. Physics Team Academic Director" in the subject line. The position will be open and applications accepted until filled. Letters of recommendation from your two references in support of your applications will only be solicited from short listed candidates. We anticipate that the individual selected will serve as co-director during the transition year and then become director the following year. For more information, contact Beth Cunningham, AAPT Executive Officer, via email at eo@aapt.org.

PhysicsBowl Academic Coordinator Wanted

Each year, AAPT sponsors a special contest (the PhysicsBowl) to challenge high school students who are interested in physics. Approximately 5,000 students from around the world take a 40-question, 45-minute timed, multiple-choice test under their school's supervision. Exam questions are based on topics and concepts covered in high school physics courses of all levels. The test is given in late March and early April with winners announced in early May. The PhysicsBowl Academic Coordinator provides general oversight of the competition and has the responsibility for preparing the yearly exam.

Qualifications for the PhysicsBowl Academic Coordinator:

- Knowledge of introductory physics, test construction, test evaluation, and current trends in physics education.
- Ability to attend the AAPT National Meetings during which the PhysicsBowl Advisory Committee will develop and evaluate questions on the exam.

Responsibilities of the PhysicsBowl Academic Coordinator:

- Develop the annual PhysicsBowl Contest Exam, including the grading and distribution of exam scores analysis to high schools (which requires some technical support to handle the scoring and analysis).
- Work collaboratively with the PhysicsBowl Advisory Committee to construct the test, discuss changes and additions to the PhysicsBowl contest, and provide annual reports on the exam outcomes.
- Develop the rules and guidelines for each year's contest.
- Correspond with students, students' parents, teachers, and AAPT staff members regarding the PhysicsBowl Contest.
- Work with partners such as ASDAN China and WebAssignTM that administer the contest for specific audiences.
- Traveling to AAPT National Meetings and meeting with the PhysicsBowl Advisory Committee.

Travel expenses (including transportation and lodging for 3 nights at the meeting hotel) will be provided for each National Meeting. In addition, the PhysicsBowl Academic Coordinator will receive an honorarium. The time commitment mostly is episodic with approximately 5 hours/week in March and April and peaking at the end of April and early May with approximately 30 hours during the week that scores are returned. Additional time is spent throughout the year preparing for the next year's exam.

See http://aapt.org/Programs/PhysicsBowl

To apply, please provide a statement of interest, a current c.v., and the names and contact information of two references (preferably AAPT members). Materials should be sent to programs@aapt.org with "Application for PhysicsBowl Academic Coordinator" in the subject line. The position will be open and applications accepted until filled.

For more information, contact Tiffany Hayes, Director, Programs and Conferences, via email at programs@aapt.org or Beth A. Cunningham, AAPT Executive Officer, via email at eo@aapt.org.

Session SPS: SPS Undergraduate Research and Outreach Posters

Location: CC - Event Center I
Sponsor: AAPT/SPS
Date: Sunday, July 23
Time: 8–10 p.m.

Presider: Brad Conrad

SPS01: 8-10 p.m. Influence of a Grounding Strip Conductor Plate on Uniform Electric Field and its Numerical Simulation

Poster – Hui Zhong, Southeast University, Nanjing, Jiangsu 211189; 2023589808@qq.com

The influence of a grounding strip conductor plate on uniform electric field is studied by conformal "mapping and reset function method" and electric potential distribution and electric field intensity distribution are obtained. Furthermore the distribution of electric field is numerical simulated by using the software MATLAB.

SPS02: 8-10 p.m. Magnetic Dynamics of Iron-based Super conductors

Poster – Zhenxiong Xie, Sun Yat-sen University, No.120 Building, Sun Yat-sen University, No.135 Xingangxi Road, Guangzhou, Guangdong 510275 P R China; zhenxiong.xie@yahoo.com

Since high-Tc superconductors were found in 1986, iron-based superconductors are practical in material science because they have higher superconducting transition temperature, larger coherence length and smaller anisotropy comparing with copper oxide superconductors. Near the instability of the antiferromagnetic order, iron-based superconductors display high-Tc superconductivity. Therefore, the magnetic structures in the parent compounds have been studied deeply. This study reports single magneton excitation and double magnetons excitation of various magnetic structures in iron-based superconductors. The effect of itinerant electron on local magnetic moment and magnetic excitation is also described.

SPS03: 8-10 p.m. On the Falling of a Rigid Body

Poster – Jiale Cheng, Southeast University Jiulonghu Campus, Nanjing, Jiangsu 210000 China; 2487548428@qq.com

In this paper, we analyze the falling process of a rigid rod with non-uniform weight distribution. The horizontal movement of the bottom and the falling time on the rough surface is studied theoretically and experimentally. We find that the rod with certain weight distribution can display a perking phenomenon at its bottom. Our experimental results coincide with our theory very well.

SPS04: 8-10 p.m. On the Force Between the Magnet and the Steel Plate

Poster – Youyou Bian, Southeast University, Nanjing, Nanjing, China 211189; whp_yy@163.com

There is a popular believe that the force between the magnet and the steel plate is always a repulsive force. However, we can derive theoretically that when the magnet approach the steel plate slowly, there will be a repulsive force between them. An experiment is made to verify the theory. During the experiment process, an obvious experimental phenomenon can be observed in a certain area.

SPS05: 8-10 p.m. On the Hot Water Fountain

Poster – Junji Hou, Southeast University, Nanjing, Jiangsu, China Nanjing, Jiangsu 211189 China; 1223887055@qq.com

Partially filled with hot water and covered by the mouth of the pipe, a pipette can eject water column on the tip, which is a so-called hot water fountain. By using the Bernoulli equation, we analyzed the max jetting height of the fountain. We found that the max height of the fountain first increased and then decreased along with the increase of water absorption and the max height of the fountain increased as the temperature increased. And our experimental results coincide with our theory perfectly.

SPS06: 8-10 p.m. Stretching an Elastic loop: Crease and Pop Out

Poster – Yinghui Li, Southeast University Nanjing, Jiangsu 211189; 842592491@qq.com

Wenhan Xu

When a loop is introduced and pulled from the both sides, ribbons with different center line spacing will show three kinds of shape transitions, crease, pop out and helicoid. In this paper, we mainly focus on the crease-pop out transition. We design an experiment to measure the relationship between thickness and critical value of center line spacing. Our experimental results reveal a power function between these two quantities, which coincides with the elastic model perfectly. Moreover, effects of temperature and ribbon structure on the critical value are also studied qualitatively.

SPS07: 8-10 p.m. Tests and Analysis of Photomultiplier Tube

Poster – Tian Xie, Yat-Sen University Sun Yat-Sen University, No. 135, Xingang Xi Road Guangzhou, Guangdong 510275 China xie_tian2015@icloud.com

Yixin Xu Sun, Danyuan Zhuo, Dexin Li, Sun Yat-Sen University

With the rapid progress of scintillation detectors, photomultiplier tube (PMT) as an indispensable part of detectors need to be studied more thoroughly. In our experiment, using LED, high voltage supply module and oscillation, PMT is tested and its properties like dark current are measured. Finally experiment data is compared with theoretical value to decide whether experimented PMT is in good state and can be used in further research.

SPS08: 8-10 p.m. The Effect of iPad-based Curriculum on Pre-Service Teachers' Content Knowledge and Technology Self-Efficacy

Poster – Matthew J. Conway, Towson University 8000 York Road, Towson, MD 21252; mconwa9@students.towson.edu

Deepika Menon, Towson University

Meera Chandrasekhar, Dorina Kosztin, University of Missouri-Columbia

As mobile technologies continue to become increasingly popular, education programs are implementing tools such as iPads, smart phones, etc., into their curriculums. This shift towards technology-based curriculums demands that pre-service teachers become efficient in these modes of teaching, however, it seems many of them do not have the confidence or experience to do so. This lack of confidence highlights the importance of college preparation for preservice teachers in regards to technology and its integration in the classroom. Exploring Physics is an innovative iPad-based curriculum with an array of tools to assist both the teaching and learning of science. Our study focuses on whether exposing pre-service teachers to Exploring Physics over a semester long physics content course 1) increases overall physics content knowledge, 2) increases self-efficacy for technology integration, and 3) if there is a correlation between changes in content knowledge and changes in technology self-efficacy.

SPS09: 8-10 p.m. Use of Popular Media in Teaching Introductory Physics

Poster – Matthew R. Hezseltine, Morehead State University, Department of Physics, Morehead, KY 40351; mrhezseltine@moreheadstate.edu

Kent J. Price, Morehead State University

Can popular media be used in as a tool to improve the teaching of introductory physics? Through this research, popular television shows and movies (especially the Big Bang Theory) were reviewed for mentions and examples that could be used in a classroom. A lesson on Newton's second law based on scenes from the movie *Superman* and the television show the Big Bang Theory was developed and tested. Results from this and a traditional lesson are being analyzed and will be presented.

SPS10: 8-10 p.m. Aerodynamic Properties of Badminton Shuttlecocks Lacking Partial Feathers

Poster Ge Yan Southeast University, Southeast University,Nanjing Nanjing, Jiangsu 211189; China 1968463198@qq.com

rui yuan, Southeast University

yiling ma, Southeast University

Affected by feathers, badminton always show unique properties during its flight. In this article, we study the trajectory, the rotation, the coefficient between rotational velocity and translational speed and some other properties of a badminton shuttlecock that lacks parts of its feathers. We design an experiment to measure the relationship between the translational speed and the rotational velocity with certain number of feathers. Our experimental results perfectly coincide with our theory.

SPS11: 8-10 p.m. Analyzing Buoyancy Lab Modalities

Poster – Emily Raker, Mercyhurst University, 501 E 38th Street, Erie, PA 16546-0001; eraker82@lakers.mercyhurst.edu

Dyan Jones, Mercyhurst University

Classifying the needs of students within the laboratory can be masked by the different deliveries of lab material, and has been shown to affect student learning. Many have proposed different hypotheses on how the delivery of lab material has affected student learning in both positive and negative ways. Existing research differs from what is presented here by means of delivery modes. Students were first asked a few conceptual questions about buoyancy to obtain a baseline. Buoyancy content was then presented to students in the lab setting, but by means of different forms: traditional hands-on, computer aided, or computer simulation. After the completion of the lab, students were asked a series of questions to see if knowledge has been obtained. Being able to effectively identify the needs of the students will allow instructors to use the laboratory setting most effectively to increase student learning.

SPS12: 8-10 p.m. Application of Neural Networks on Numerical Simulation of CMB

Poster – Siqi Dong, School of Physics, Sun Yat-sen University, No. 135 West Xingang Road Guangzhou City, Guangzhou, Guangdong 510275; China 1244538102@qq.com

Numerical simulation is usually used to predict the cosmic phenomena under various models, and compared with astronomical observations. However, numerical simulation involving cosmology is always of high requirement for computer's operation ability, therefore we use the neural network as the "database" of a large-scale numerical simulation— using the outcomes of the numerical simulation of a model on a super computer for training the neural network, so as to obtain the database— input relevant constants and the corresponding numerical simulation outcomes can be obtained. In the case of CMB, a numerical simulation software calculating the energy spectrum of the Cosmic Microwave Background radiation, CAMB, is used to obtain data and train the neural network. Then the calculation of the trained neural network is compared and evaluated.
Fuli Zhao, professor of the School of Physics, Sun Yat-sen University

SPS13: 8-10 p.m. Behind Quantum Mechanics

Poster – Xing Guo, seu, NanJing, jiangsu 211111; higuoxing@outlook.com

SPS14: 8-10 p.m. Elementary Teachers Recognize and Support Sophisticated Energy Learning

Poster – Sierra Decker, Seattle Pacific University, 3018 4th Ave. W, Seattle, WA 98119; deckers@spu.edu

Eric Bolander, Jocelyn Ferriera Lane Seeley, Abigail Daane Seattle Pacific University

Focus on Energy (FOE) is a research and development project that aims to provide elementary students with opportunities for sophisticated science reasoning in the context of energy. FOE is a collaborative effort between researchers and teachers in Seattle and Boston. The project's goal is to develop and use particular curricula and formative assessment resources to support elementary teachers in creating substantive and engaging energy learning opportunities for their students. This support is provided in various forms: intensive professional development during the summer, possible activities and supplies to use in their classrooms, and professional development in person and online during the school year. We have developed several forms of assessment to identify growth in teachers' content knowledge, knowledge of student ideas, and pedagogical content knowledge. In this presentation, we share some preliminary results that showcase the teachers' work in thinking about energy and instruction.

SPS15: 8-10 p.m. Exploring Physics Understanding of Urban English Language Learners??

Poster – Alanna M. Blanchard, Mercyhurst University, 25 Roger St., Frewsburg, NY 14738; ablanc51@lakers.mercyurst.edu

The purpose of this study is to explore factors influencing ESL student comprehension of physics concepts. ESL students are one of the fastest growing populations in K-12 education in the United States and best practices for content area teachers in addressing the needs of this population is an increasingly important research topic. This project was performed at the Quality of Life Learning Center in Erie, PA. Participants include a refugee based population of students in grades 10-12 attending the center. Data were gathered in both interview questionnaire and video form. Students attended classes after school taught by the researcher. These classes were followed by semi-structured interviews with the student's aimed at illuminating the specific aspects of lessons and teaching techniques that improve conceptual understanding of key physics content topics from the lessons. Class assessment results was also analyzed to compare conceptual understanding across different teaching techniques.

SPS16: 8-10 p.m. What Does "Virtual" Mean in the Virtual Displacement?

Poster – Jixuan Hou, Southeast University, Nanjing Nanjing, Jiangsu 211189; 36752876@qq.com

Virtual displacement is an important physical concept in physics. For exaggerating the role of the "non-reality in applications of the virtual displacement" we analyze how the virtual displacement is applied which can be divided into three steps: 1) for a given physical problem the definition of virtual displacement of a variable is introduced; 2) the variation of a mathematical function along the change of the virtual displacement is given, which is not necessarily compatible with physics principles; 3) with imposing physical conditions on the mathematical function—the physics consequence is resulted.

SPS17: 8-10 p.m. Implementing a Student Driven First-Year Mentoring Program

Poster – Patrick J. Carroll, Miami University, 500 E. Spring Street, Oxford, OH 45056; carrolpj@miamioh.edu

Sara M. Zanfardino, Jennifer Blue, Miami University

Many educational researchers in STEM fields strive to improve undergraduate retention while simultaneously improving quality of education. Last year at Miami University, 0.39% of all Bachelor degrees awarded were in physics, which is 24% lower than the national average of 0.51%. Many factors influence a student's decision to continue pursuing a degree in physics after their first year of study. It was hypothesized that some major contributors to the decision-making process included misconceptions first-year students have regarding job opportunities post-graduation and feelings of isolation throughout the first two years of fulfilling degree requirements due to the nature of the course scheduling (i.e. there is little to no collaboration between underclassmen and upperclassmen or graduate students in freshman and sophomore academic courses). A mentor program, organized by upperclassmen and graduate student volunteers, was examined to determine its effect on these hypothesized factors and apprehensions.

Session AA: Cultural Perspectives on Educational Technology

Location: Marriott - Covington Ballroom I
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on International Physics Education
Date: Monday, July 24
Time: 8:30–10 a.m.

Presider: Andre Bresges

AA01: 8:30-9 a.m. Effects of Video-based Motion Analysis in University Recitations (Mechanics)

Invited – Pascal Klein, University of Technology Kaiserslautern, Erwin-Schrödinger Straße 46, Kaiserslautern, RLP 67663 Germany; pklein@physik.uni-kl.de

Michael Thees, University of Kaiserslautern

Müller Andreas, University of Geneva

In this contribution we report the results of a quasi-experimental, intervention-control-group studies concerning undergraduate physics courses. In the setting of weekly recitations, students adapted their theoretical knowledge to application-oriented problems. Traditional paper-and-pencil based exercises have been extended with video-based experiments that can be analyzed quantitatively (so-called video-based motion analysis tasks, VBMA tasks). This allows a deeper connection between theory and experimentation. After students gained first experiences with VBMA tasks, they conducted hands-on experiments themselves, recorded them and analyzed them with mobile devices (mobile VBMA tasks). Within the scope of this research and development project, we (1) designed instructions referring to such video-experiments, (2) investigated the feasibility of our approach for large lecture courses (N > 50), (3) investigated students' learning and motivation with standardized instrument with intervention- and control-groups, and (4) developed and validated new assessment instruments (focusing on representation competency and authenticity).

AA02: 9-9:30 a.m. The Electron Gas Model: A German-American Perspective on Teaching Electricity

Invited – Jan-Philipp Burde, Goethe-Universität Frankfurt, Department of Physics Education Research, Max-von-Laue-Str.1, Frankfurt am Main, Hessen 60438 Deutschland; burde@physik.uni-frankfurt.de

Thomas Wilhelm, Goethe-Universität Frankfurt

Understanding the basic concepts of electricity represents a major challenge to most students. In particular, most learners do not succeed in developing a robust understanding of voltage or potential and instead tend to reason exclusively with current and resistance. Similarly to the CASTLE curriculum, the proposed teaching concept links students' everyday experiences with air pressure (e.g. bicycle tires) to the concept of "electric pressure", which serves as a prototype conception of the electric potential. By using the air analogy, the teaching concept seeks to provide students with a powerful mental model of basic electrical quantities and enable them to qualitatively reason about electric circuits. After comparing German and US approaches to teaching electricity, the presentation will give an introduction to the key ideas of the teaching concept. Additionally, it is planned to reflect upon the research methods used in its development and assessment from a cultural perspective.

AA03: 9:30-9:40 a.m. Investigating Student Motivation and GTA Teaching Beliefs Towards Smartphone Technology

Contributed – Sam Sridhar, North Carolina State University, 2401 Stinson Drive, Raleigh, NC 27695-8202; ssridha5@ncsu.edu

Colleen Countryman, North Carolina State University

The NC State Physics Department has developed a new type of lab course for introductory mechanics courses. One aspect of this new lab course is to provide students with the option of using their own smartphones' internal sensors for data collection. Our ongoing project—titled "MyTech," or "Measurements using everydaY TECHnologies"—involved developing a new curriculum, creating a mobile app, and investigating the impact of students' smartphones on their learning of physics concepts. The purpose of this pilot study is twofold: to qualitatively evaluate the impact of implementing the MyTech app on GTA (Graduate Teaching Assistant) teaching beliefs towards smartphone technology, and to establish a correlation between student motivation to use the MyTech app and graduate TA teaching beliefs towards smartphone technologies. We utilized a mixed method approach consisting of a five-point Likert assessment to quantitatively measure student motivation in introductory mechanics labs, as well as one-on-one interviews with GTA's.

Session AB: Neutrino Physics Investigations for Students and Teachers

Location: Marriott - Covington Ballroom II
Sponsor: Committee on Modern Physics
Co-Sponsor: Committee on Physics in High Schools
Date: Monday, July 24
Time: 8:30–10 a.m.

Presider: Kenneth Cecire

AB01: 8:30-9 a.m. Probing the Secrets of the Universe Using Neutrinos

Invited – Sowjanya Gollapinni, University of Tennessee, Knoxville, 515 Nielsen Physics, 1408 Circle Drive, Department of Physics and Astronomy, Knoxville, TN 37923; sgollapi@utk.edu*

In the world of subatomic physics, neutrinos form the most bizarre tiny entities known to date. Scientists study these elusive particles to understand the biggest puzzles in the universe, from the structure of the atom to the formation of a star. Although more than a trillion of these particles pass unnoticed through our bodies every second, neutrinos still remain largely mysterious given how rarely they interact with normal matter. In your entire lifetime, perhaps one neutrino will interact with an atom in your body. Furthermore, their ability to morph into one another makes it even more challenging to detect them. Despite all this, researchers have managed to capture a handful of neutrinos by building large and sensitive detectors in some of the remote places on Earth. This talk will review the current status of neutrino physics and will highlight some of the exciting experimental endeavors taking place around the world.

*Sponsored by Kenneth Cecire

AB02: 9-9:30 a.m. Neutrino Experiments Inspire Students

Invited – Marla Jane Glover, Rossville High School, 606 S 21st, Lafayette, IN 47905; mglover@rcsd.k12.in.us

Many students in high schools have misconceptions about frontier science experiments. They may think that there is nothing new for them to discover or that they do not have the background necessary to understand what is happening in these experiments. Yet students can use classical physics to analyze neutrino experimental data and draw conclusions. This talk will describe my students' analysis of neutrino data through conservation of momentum. The audience can participate as students for a very brief time to get the feel of being the investigator. I will also share the reaction of my students to using this activity.

Session AC: Defining Units: Old and New

Location: CC - Ballroom C
Sponsor: Committee on the Interests of Senior Physicists
Date: Monday, July 24
Time: 8:30–10 a.m.

Presider: Tom O'Kuma

AC01: 8:30-9 a.m. An Introduction to the New International System of Units (SI)

Invited – Peter J. Mohr, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899; mohr@nist.gov*

Physical science is based on measurements, and the results of measurements are expressed in terms of units. Even though a majority of people in the U.S. still use units such as inches and pounds, the official standards for these units are linked to the International System of Units (SI). For example, the U.S. definition of the inch is that it is exactly 2.54 cm. The Treaty of the Meter that specifies exactly how units are defined was established in 1875 with 17 nations initially signing on, including the U.S. The SI, established within the treaty in 1960, is more recent and continues to evolve; plans have been made to redefine the SI around 2018. This talk will describe the new SI, review the reasons for the change, and show how units will be based on assigned values of certain physical constants.

*Sponsored by Tom O'Kuma.

AC02: 9-9:30 a.m. The New Definition of the Kilogram in the Revised International System of Units

Invited – Stephan Schlamminger, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899; stephan.schlamminger@nist.gov

A change to the International System of Units (SI) is currently under discussion and might become effective in 2019. This revision will change the foundation of the SI from base units to fundamental constants. For example, the definition of the unit of mass, the kilogram, which is presently given via an artefact, will be realized by using fixed values of three fundamental constants, the speed of light, the hyperfine structure of Cesium, and the Planck constant. Researchers at NIST have built a Kibble balance, formerly known as watt balance, to measure the mass of an object using these three defining constants. During this talk the principle of the Kibble balance will be explained using a working model, the NIST DIY watt balance.

AC03: 9:30-9:40 a.m. Using History to Take the Mystery Out of Units

Contributed – Robert A. Morse, Emeritus, St. Albans School, 5530 Nevada Ave., Washington, DC 20015-1784; ramorse@rcn.com

Units in physics in the U.S. are trickier for introductory students than in most of the world as our "homely and familiar" units differ from our physics units. For years I have taken time to do a quick review of the history of units (a fascinating study in itself) in the context of providing practice with unit conversion, and tying values of units to familiar objects. I will give a quick overview of some of the units and their stories I have used in this endeavor.

AC04: 9:40-9:50 a.m. What I Want Students to Know About Units

Contributed – Charles H. Holbrow, Colgate University/MIT, 231 Pearl Street, Cambridge, MA 02139-4510; cholbrow@colgate.edu

I argue it is more useful for students to know the historical definitions of SI units—a kilogram is the mass of a liter of water, a meter is 1/10,000,000 of a quadrant of Earth's circumference, and a second is about a heartbeat or the half-period of a 1-meter long pendulum on Earth—than to know the IUPAP definitions of SI mass, length, and time. Students need to understand the difference between units and dimensions: why the speed of light can be in tablespoons per barn-weekend and to check equations for dimensional consistency. I want them to know SI multipliers and to use them efficiently. I will tell you how to answer students who ask: What does it mean to have the speed of light or Planck's constant or Avogadro's number defined by international agreement?*

*My thanks to Dr. Bernard Hoop for bringing the units of tablespoons per barn-weekend to my attention.

AC05: 9:50-10 a.m. The Origin of the Metric System in Revolutionary France

Contributed – Chad L. Davies, Gordon State College, 419 College Dr., Barnesville, GA 30204-1762; c_davies@gordonstate.edu

The metric system was born out of the economic and cultural forces that gave rise to the French Revolution. These factors, along with the ideals of the Revolution, led to an idea to create a national system of units based on that thing that was common to all humanity, the Earth. I will examine the methods and technologies, specifically the refinement of surveying instruments, that led to making the measurements necessary to define a length unit based on the size of the Earth itself. This will mark a shift from a hodge-podge of anthrocentric units to an attempt to establish a unit system based on standards available to all natural philosophers. While the effort would fall short of the aspirations of its primary proponents, the data used to determine the length of a meter played an important role in developing a method for characterizing experimental uncertainty.

Session AD: Optics Labs at All Levels: Rainbows to Raman Spectroscopy

Location: CC - Breakout 4
Sponsor: Committee on Laboratories
Date: Monday, July 24
Time: 8:30–10 a.m.

Presider: Robert Hobbs

AD01: 8:30-8:40 a.m. Inexpensive Optics Apparatus for Lecture Demonstration, Outreach, or Laboratory

Contributed – David E. Sturm, University of Maine, 5709 Bennett, Orono, ME 04469; sturmde@maine.edu

Simple and reasonably inexpensive demonstration apparatus for optics can be created or purchased inexpensively. These can be used at the introductory level from even outreach to elementary schools right up through high schools and into the first-year college course laboratories. This short contributed talk will highlight some of those methods with both pictures and the actual demonstrations.

AD02: 8:40-8:50 a.m. Scads o' SPADs (Single-Photon Avalanche Diodes)

Contributed – Gabriel C. Spalding, Illinois Wesleyan University, 201 E. Beecher St., Bloomington, IL 61701; gspaldin@iwu.edu

This talk discusses some (currently) expensive technologies that are relevant to teaching quantum optics, as well as the early stages of thinking about how to leverage high-tech mass-market technologies into affordable options for instructional labs (here, focusing on labs Beyond the First Year of university). —On the back of my iPhone, between the camera and the flash, is a small dot. That dot is a single-photon avalanche diode (SPAD), with integrated electronics for Time-Correlated Single-Photon Counting (TCSPC). The phone can autofocus by sending out a pulse of infrared light and determining the time required for reflection. Similar technology is now used in some golf-course range finders, and may soon find a mass market in Advanced Driver Assistance Systems (ADAS). More generally, the emerging ADAS market is likely to be a rich source of tools for the instructional lab, for which I hope to assemble an ongoing discussion group.

AD03: 8:50-9 a.m. Simple Setup to Teach Optical Alignment

Contributed – Ashley R. Carter, Merrill Science Center, Amherst, MA 01002-5000; acarter@amherst.edu

One of the most important skills for an optical engineer or physicist is to be able to quickly and precisely align optical components. A simple laboratory to teach this skill is to align a laser beam to two irises and then to a series of two lenses that act like a telescope. A pinhole can also be added to the system to spatially filter the beam. However, this simple lab is hard to do correctly. Students often rush through the alignment or have trouble figuring out what to do. Here, we walk through the basics of the laboratory, identify student pitfalls, and discuss keys to success.

AD04: 9-9:10 a.m. Smartphone-based Projects for Modern Optics Class

Contributed – Yiping Zhao, University of Georgia, 220 Riverbend Road, Athens, GA 30602-0001; zhaoy@physast.uga.edu

Smartphones, with their advances in opto-electronic sensing, motion sensing, and geo-referencing capabilities, provide unique opportunities to significantly increase students' interest in optics education, as well as improve their experimental and data analysis skills. Since 2014, smartphone-based optics projects have been incorporated into a one-semester modern optics course. I will demonstrate how within two months, with proper guidance and a broad selection of topics, students can use smartphones to go from demonstrating basic optical principles, to work through instrument design and optimization, and ultimately to realize applications in environmental sensors, biomedical imaging, and astrophysics. These projects evolve from smartphone-only designs, to combining LEGO blocks, and then incorporating 3D printing. This stimulates more interest from the students, and, by including state of the art manufacturing, also improves their career training. I argue that these optics projects can also be used in K-12 education and disseminated via social media to promote public interest.

AD05: 9:10-9:20 a.m. The Optics Involved in the Debye-Sears Experiment

Contributed – Karen A. Williams, East Central University, 1100 E. 14th St., Ada, OK 74820; kwilliams@ecok.edu

Optics is used in many medical, chemical, industrial, athletic, and other areas. We all come into contact with and use optics every day. I teach an ultrasound physics lab where students may be pre-medical, pre-physical therapy, pre-engineering, medical physics, or physics majors. Due to the diversity of backgrounds in the course, I have my students do an optics lab that utilizes the Debye-Sears Effect with ultrasound and a laser to measure the velocity of sound in saltwater and compare it to a theoretically calculated value. The students describe other ways that this apparatus or experiment may be used. The optics in this sound experiment will be discussed.

AD06: 9:20-9:30 a.m. Using a Michelson Interferometer to Detect Sounds

Contributed – Timothy Todd Grove, IPFW, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805; grovet@ipfw.edu

We present a laser experiment for students beyond their first year in physics. This experiment not only gives students experience with laser interferometry, it also provides cross course learning (electronics) and play. The experiment is based upon a Michelson interferometer; a sound source vibrates one of its reflecting mirrors to produce a time changing signal. Usually the sound source is a radio connected to a small speaker, but students are free to play with other sound vibrating schemes. The interference fringes vibrate with frequencies similar to the sound source. A photodetector then detects the changing fringes and a simple computer program converts the photo signal into an audio file. Simple electronics circuits provide access to the radio signal sent to the sound speaker. Then by comparing the "true" radio signal with the signal recorded via the photodetector, we can analyze the performance of our sound recording system.

AD07: 9:30-9:40 a.m. Inquiry Activities in a Light and Color Course

Contributed – Robert Hobbs, Bellevue College, 3000 Landerholm Circle SE, Bellevue, WA 98007; rhobbs@bellevuecollege.edu

We have implemented a light and color course aimed at Arts and Science students with an emphasis on those in the visual arts (theater, photography, interior design). This talk will present several unique activities along with samples of student work stimulated by these activities. The focus is activities that generate productive discussion or those that appear to reliably lead to developing appropriate concepts (e.g. color addition or subtraction rules, image formation, etc).

AD08: 9:40-9:50 a.m. Teaching Effective Visual Observation Skills in the Optics Lab

Contributed – Catherine Herne, SUNY New Paltz, 1 Hawk Drive, New Paltz, NY 12561; hernec@newpaltz.edu

A significant skill in all optics research is effective observation, from illustrating research findings to drawing conclusions based on visual observations. Instructors in lab courses expect students to be able to draw good diagrams and get useful information from them, but students typically aren't taught how to make independent and effective observations. We show our technique for training students in observational skills through self-reflection and instructor feedback. In our advanced physics laboratory course, students draw diagrams of their experimental arrangements and of their optical images and data, and reflect on their drawings repeatedly throughout the semester. They build on feedback they receive on the usefulness of their diagrams. In this session, we will demonstrate this visual observation skills technique that the students used, show a selection of our data, and report our outcomes. Participants will try a visual observation exercise, and apply their insights to their own disciplinary teaching.

AD09: 9:50-10 a.m. Optics: A Bridge from Introductory Physics to Advanced Courses

Contributed – Marta L. Dark, Spelman College, 350 Spelman Lane SW, Box 1703, Atlanta, GA 30314-4399; mldark@spelman.edu

The optics course at Spelman College is a laboratory-based course for physics and dual-degree engineering majors. We replaced our traditional Physics III course (optics and modern physics), with two separate courses, "Oscillations and Waves" and "Optics". The department saw a need to further develop the intellectual maturity and critical thinking skills of our majors before they moved to advanced courses. Along with introducing geometrical and physical optics, the intent of this course is to aid physics majors with the transition from the introductory sequence to the upper level curriculum. Optics emphasizes experimental design, the development of practical lab skills, data analysis, and communicating physics to varied audiences. I will present some of the pedagogy and assessment tools used in this bridging course.

Session AE: Frontiers in Astronomy

Location: CC - Breakout 5
Sponsor: Committee on Space Science and Astronomy
Date: Monday, July 24
Time: 8:30–10 a.m.

Presider: Richard Gelderman

AE01: 8:30-9 a.m. Building Supermassive Black Hole Binaries

Invited – Kelly Holley-Bockelmann, Vanderbilt University, 2105 10th Ave. S, Nashville, TN 37204; kelly.gravity@gmail.com

Astronomers now know that supermassive black holes reside in nearly every galaxy. Though these black holes are an observational certainty, nearly every aspect of their evolution—from their birth, to their fuel source, to their basic dynamics—is a matter of lively debate. In principle, gas-rich major galaxy mergers are key to generate the central stockpile of fuel needed for a low mass central black hole "seed" to grow quickly and efficiently into a supermassive one. When the black holes in each galaxy meet, they form a supermassive binary black hole, the loudest gravitational wave source in the Universe, with the energy to transform its galactic host. This talk will touch on some current and ongoing work on refining our theories of how supermassive black hole binaries grow, evolve within, and alter their galaxy host.

AE02: 9-9:30 a.m. Finding Planets by Chemical Signatures in their Host Stars

Invited – Eileen D. Friel, Indiana University, 727 East 3rd Street, Bloomington, IN 47405-2618; efriel@indiana.edu

Over 3000 extrasolar planets have been confirmed and an equal number of candidates await confirmation. The many systems discovered are diverse and the relationships between their properties are key to informing theories of planetary formation. Among the earliest and most surprising results was the apparent correlation between the frequency of planetary systems and the overall abundance of heavy elements, or the metallicity, of the host star. More recent work has taken advantage of the ability to measure extremely precise stellar elemental abundances to reveal an unexpected and intriguing correlation between the detailed chemical abundance pattern in the host stars and the presence of rocky planets. These abundance patterns may, themselves, offer another pathway to identifying Earth-like planets around other stars as well as shedding light on the formation and evolution of both these planetary systems and their host stars.

AE03: 9:30-10 a.m. Globular Clusters, Galaxy Formation, Dark Matter, and Black Holes

Invited – Katherine L. Rhode, Indiana University 727 E. Third Street, Bloomington, IN 47405; krhode@indiana.edu

Globular clusters are spherical star clusters with thousands to millions of stars packed into a region only a few light years across. These clusters are extremely luminous and are among the oldest objects in the Universe. Globular clusters exist in all types of galaxies, from low-mass dwarfs to giant elliptical galaxies. Together these properties make globular clusters valuable "fossil records" that provide crucial clues about the formation history of their host galaxies. I will describe results from a wide-field optical imaging survey of the globular cluster populations of giant galaxies and explain what they tell us about how galaxies formed and evolved in the first few billion years after the Big Bang. I will also show how the globular clusters identified in the survey are being used to investigate the dark matter distribution of their host galaxies, and how they helped us discover the first black holes in globular clusters.

Session AF: Science and Society

Location: CC - Breakout 6
Sponsor: AAPT
Date: Monday, July 24
Time: 8:30–9:10 a.m.

Presider: Dallin Durfee

AF01: 8:30-8:40 a.m. Human and Robotic Spaceflight: The Past and the Future

Contributed – Frank D. Lock, Georgia State physTEC, 4424 Sardis Rd., Gainesville, GA 30506; flock@gsu.edu

Humans and robots will spend time on Mars working together. There is a rich history of human exploration in space, and robotics have been a key to the success of that exploration. This talk will highlight that history and how it will affect future exploration. Using space exploration concepts in the classroom will be described, as well as the role of physics in the success of future space exploration endeavors.

AF02: 8:40-8:50 a.m. Leveraging Physics Education Research to Understand Informal Physics Environments

Contributed – Kathleen A. Hinko, Michigan State University, 919 E. Shaw Ln., East Lansing, MI 48825; hinko@msu.edu

Claudia Fracchiolla, University of Colorado Boulder

Outside of the classroom, physicists and physics students often design and teach in informal programs targeted at youth and public audiences. There are many open questions about the impact of these informal environments on both learners and teachers in terms of building physics identity, interest, and content-knowledge. We advocate for bringing the frameworks, tools, and techniques of physics education research to bear on informal physics learning settings. We will describe some methodological strategies for investigating teaching and learning for different types of informal physics programs. In addition, we put out a call to others interested in engaging in evaluation and research in informal physics to build a community through which we can provide each other with support, collaboration and resources.

AF03: 8:50-9 a.m. The Impact of Peace Corps Volunteer Science and Math Teachers in a Developing Nation

Contributed – Jonathan C. Hall, Penn State Erie - The Behrend College, 4205 College Drive, Erie, PA 16563-0203; jch12@psu.edu

In 1963, when the country of Malaysia was formed from the Federation of Malaya and the British colonies of Sarawak and North Borneo (Sabah), education was limited (especially in rural areas) due to a lack of qualified teachers. From 1962 until 1983, Peace Corps volunteer science and math teachers helped educate a generation of Malaysian students. Data of the impact of one of the Peace Corps volunteer teachers in rural Sabah will be presented.

AF04: 9-9:10 a.m. And… Action! Theater and Cordel in Physics Outreach for Children

Contributed – Katemari D. Rosa, Federal University of Bahia, Av. Cardeal da Silva, 213 apt 37 - Federacao, Salvador, BA 40231-305; Brazil katemari@gmail.com

Roberta Smania-Marques, Paraiba State University

Maria Ruthe Gomes, Julio Cesar S Nascimento, Heloisa G Barbosa, Federal University of Campina Grande

In this presentation, we share our experience developing and conducting physics outreach activities for children between four and 10 years old. The literature on science education and physics education, in particular, has shown art can play an important role in teaching and learning. Based on studies that focus on theater as a means of science popularization and on a traditional regional Brazilian art form, namely the Cordel literature, we developed a theater play that intertwines ideas around friendship, concepts of light and color, and fun. Cordel literature is a popular and inexpensive literature produced, mostly, in Northeastern Brazil. In this art form, printed booklets bring folk novels and poems, using specific types of rhyme. These booklet topics range from daily life events, romance, politics, and social critics. The connections between children's cultural roots, art, and science throughout this project bring an alternative for children's physics education.

Session AG: Physics Majors: High School to Doctorate

Location: CC - Breakout 7
Sponsor: AAPT
Date: Monday, July 24
Time: 8:30–9:10 a.m.

Presider: TBA

AG01: 8:30-8:40 a.m. CLASS's Personal Interest: Connections to Belonging, Performance, Retention, and Gender

Contributed – Mike A. Lopez, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; lopez.559@osu.edu

Hanna M. Lafranconi, Andrew F. Heckler, The Ohio State University

Studies in equity in physics education have shown personal interest in physics to be a key predictor of retention. To further investigate this factor and other potential factors, we administered a survey to 153 undergraduate STEM majors (about 100 were physics majors) enrolled in first through fourth-year level physics courses. The survey consisted of items assessing personal interest and other categories in the Colorado Learning Attitudes in Science Survey and over 15 other validated scales such as belonging, intent-to-drop, mindset, and values. Employing linear regression models, we present preliminary results indicating that while personal interest does predict grades and intent-to-drop, the factor of belonging may be a much stronger predictor and may be a mediating factor in such predictions. We also find evidence that there are no gender differences in personal interest in physics for physics majors, but for non-physics majors, women reported significantly less personal interest in physics.

AG02: 8:40-8:50 a.m. Comparing the Perspectives of Students and Faculty on Graduate Admissions*

Contributed – Deepa N. Chari, STEM Transformation Institute, Florida International University, 8951 SW 72nd St., Miami, FL 33173; deepu.chari@gmail.com

Geoff Potvin, STEM Transformation Institute, Florida International University

Certain admission criteria often weigh heavily on the outcome of graduate applications in physics. Thus, it is important to convey to prospective graduate students which, and how, various criteria are considered by graduate admission committees. Relatedly, how admissions processes are perceived by students can impact their choices and behaviors towards applying to graduate school. In this talk, we report on an analysis of the importance of several graduate admission criteria, as reported by 170 faculty (associated with PhD admissions) and 1031 undergraduate physics majors from the U.S. We identify notable agreement regarding undergraduate GPA, prior course-taking and GRE scores. On the other hand, faculty ranked several criteria including personal statements, prior research experiences, and prior publications as significantly less important than students. We will discuss the implications of these findings and further results on graduate admissions in detail.

*This work funded in part by NSF Grant # 1143070

AG03: 8:50-9 a.m. DEEP Scholars Program at the University of Georgia

Contributed – Steven P. Lewis, University of Georgia, Dept. of Physics & Astronomy, 220 Cedar St., Athens, GA 30602-0001; lewis@physast.uga.edu

Timothy Foutz, William M. Dennis, Charles Kutal, Judy Milton, University of Georgia

The Developing Excellence in Engineering and Physics (DEEP) Scholars program at the University of Georgia is a need-based scholarship program funded by the National Science Foundation. The overarching goal of the DEEP program is to increase the number of academically talented students with demonstrated financial need who earn a baccalaureate degree in engineering and/or physics and are well prepared to enter the STEM workforce or graduate study. While financial support is a key feature in enabling these students to pursue their studies, we designed the program with a variety of support structures to foster their professional growth and promote their academic success. This talk will give an overview of the design and structure of the DEEP Scholars program and provide a status report of its efficacy two years into the project.

AG04: 9-9:10 a.m. Graduate Retention in Physics: Pathway to PhD

Contributed – Sara M. Mueller, The Ohio State University, 190 Kinnear Alley, Columbus, OH 43202; mueller.352@osu.edu

Christopher Porter, Andrew Heckler, The Ohio State University

According to the American Physical Society, only 55% of graduate students who begin a PhD program complete that degree. Here, we describe the methodology and theoretical framework of a multi-year study, still it initial stages, aimed at characterizing the various pathways students navigate while enrolled in the physics PhD program at Ohio State University. Attention is paid to both the logistical and experiential components of earning a PhD in physics. Our longitudinal study includes surveys, enrollment and grades, graduate program milestone data, interviews, and focus groups of graduate students and faculty. Beyond careful description of possible student pathways, a primary goal of the study is to evaluate whether the success of graduate training depends on the path a student takes. We further anticipate that our approach will also illuminate issues that underlie poor retention for underrepresented groups.

Session AH: Innovations in Upper Division Physics Classes

Location: Marriott - Covington Ballroom III
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 24
Time: 8:30–10 a.m.

Presiders: Jeff Saul, Rebecca Lindell

AH01: 8:30-9 a.m. Reinvigorating Upper Division Mechanics: Introducing Students to a Complex World

Invited – David Nolte, Dept. of Physics and Astronomy, 525 Northwestern Ave., West Lafayette, IN 47907; nolte@purdue.edu

The best parts of physics are the last topics that our students ever see.

These are exciting topics like the bending of light by black holes, traffic on the World Wide Web, or the synchronization of global economies. A new approach to teaching upper-division mechanics concentrates on the time evolution of physical systems as trajectories through abstract spaces, providing a common and simple mathematical language. Given the growing importance of dynamical systems in science and technology, this approach gives students an up-to-date foundation for their future careers, embedding topics of modern dynamics—chaos, synchronization, network theory, neural networks, evolutionary change, econophysics and relativity—within the context of traditional physics founded on Lagrangian and Hamiltonian physics. The goal of this approach is to modernize the teaching of junior-level dynamics, responsive to a changing society, while retaining the core traditions and common language of dynamics texts.

D. D. Nolte, *Introduction to Modern Dynamics: Chaos, Networks, Space and Time* (Oxford, 2015)

AH02: 9-9:30 a.m. Paradigms 2.0: Supporting Collaborative Departmental Change*

Invited – Corinne Manogue, Oregon State University, Dept. of Physics, Corvallis, OR 97331; corinne@physics.oregonstate.edu

Emily van Zee Oregon, State University

The whole Paradigms 2.0 Team Oregon State University

The Paradigms in Physics program began 20 years ago at Oregon State University. In those two decades, we not only completely restructured the content trajectory for majors to be more aligned with how professionals think about the content, but we also designed many course activities which reflect our not only our own education research but also results from other PER and DBER groups. In the past two years, we have chosen to revise and update the program to reflect new research interests among department faculty and to allow us to incorporate holistic changes that could not be addressed iteratively. Along the way, we have been documenting and studying our change process. We will share insights from the change process about how to support faculty in collaboratively implementing curriculum reform based on education research.

*Supported in part by NSF DUE 1323800.

AH03: 9:30-10 a.m. Mapping Backward from STEM Careers to the Upper-Division Curriculum

Invited – Benjamin Zwickl, Rochester Institute of Technology, School of Physics and Astronomy, RIT, 84 Lomb Memorial Dr., Rochester, NY 14623; ben.zwickl@rit.edu

Kelly Martin, Anne Leak, Rochester Institute of Technology

The upper-division physics curriculum prepares students for many options after graduation through an emphasis on transferrable skills such as problem-solving, mathematical modeling, and technical writing. Using more than 50 in-depth interviews with entry-level employees and academic researchers in optics and photonics (a physics-intensive field), we examine mathematics, problem-solving, and communication within STEM workplaces and compare with common features of the upper-division curriculum. Emergent themes from the interviews highlight the value of many traditional practices, such as analytically intensive problem solving, but also provide context to understand why and how particular practices may support workplace objectives and when alternative methods (e.g., computational methods) are better applied. An example from communication shows that while journal-style writing to scientific peers is important, there is also a need to communicate technical ideas to those with different expertise (e.g., to management or members of an interdisciplinary team). Practical implications for the curriculum will be discussed.

Session AI: Engineering Education

Location: CC - Breakout 8
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Science Education for the Public
Date: Monday, July 24
Time: 8:30–10 a.m.

Presider: Rebecca Lindell

AI01: 8:30-9 a.m. Productive Intersections Between PER and Engineering Education: Ethics Education

Invited – Ayush Gupta, University of Maryland, College Park, Room 1320 Toll Physics Building, College Park, MD 20740; ayush@umd.edu

In this talk I will focus on ways in which physics education research and engineering education research can come together, in particular in developing ways to educate our next generation of STEM graduates to think carefully about the ethical implications of their work. Engineering education has long had a focus on professional ethics, with the principal effort directed towards developing innovative curriculum. I will discuss trends within engineering ethics education, what has been learned and what are the current pursuits of research and development. I will discuss how these advancements can help physics education researchers forge a new direction of research in PER focused on the ethical education of physics majors and how the current tools (theoretical and methodological) within PER can help us make progress in this direction.

AI02: 9-9:30 a.m. Broadening Contexts to Broaden Participation in Engineering

Invited – Morgan Hynes, Purdue University, 701 W. Stadium Ave. Rm 1315, West Lafayette, IN 47907; morganhynes@purdue.edu

Much work has been done and is being done to increase the number and diversity of students choosing an engineering career pathway. The evaluation of various curricular and programmatic interventions aimed at improving students' attitudes and beliefs about engineering have documented success in the form of increased positive gains. However, the numbers of students choosing engineering career pathways has not seen any significant change. In this interactive presentation, Dr. Hynes will present his hypothesis that current engineering education outreach activities have done a great job at appealing to students' situational interests, but not such a great job at appealing to diverse students' personal interests. The presentation will include discussion of data from a study on students' interests and understandings of engineering, a framework for engineering activities that integrate students' personal interests, and rich examples of such activities.

AI03: 9:30-10 a.m. Revolutionizing Engineering Education: New Directions for an Evolving Discipline

Invited – Monica F. Cox, The Ohio State University, 2070 Neil Avenue, 244F Hitchcock Hall, Columbus, OH 43210; cox.1192@osu.edu

The first departments of engineering education in the United States were established in 2005 followed by the creation of several new engineering education departments varying in mission, scope, student populations served, and university type. This talk highlights lessons the presenter learned as a faculty member and as a department chair in two newly created engineering education departments at research universities in the United States. Framed within the context of business, engineering education, and education literature, the talk identifies ways for leaders within any organization to connect interdisciplinary faculty and staff representing diverse backgrounds, to build cohesive communities of science, technology, engineering, and mathematics (STEM) researchers, and to introduce appropriate modes of communication inside and outside of an organization.

Session AK: PER: Exploring Problem Solving Approaches and Skills

Location: CC - Ballroom D
Sponsor: AAPT
Date: Monday, July 24
Time: 8:30–9:50 a.m.

Presider: Christopher Orban

AK01: 8:30-8:40 a.m. Characterizing Student Understanding of Units and Dimensional Analysis

Contributed – Abigail M. Bogdan, Seton Hill University, 1 Seton Hill Dr., Greensburg, PA 15601; abogdan@setonhill.edu

Nathaniel R. Amos The Ohio State University

The ability to work with and understand units is a fundamental skill in the sciences and engineering. At the college level, it is often a skill that is assumed both by students and professors; however, it is also a skill that students struggle to master. The goal of this study was to identify and categorize the roadblocks that students commonly face when working with dimensional analysis. The study was conducted with students enrolled in an introductory, calculus-based physics course at a large research university in the United States. Over 300 students were given a sequence of questions on dimensional analysis, and a subset of these students were interviewed about their responses. We analyzed student responses, categorizing common errors and solution strategies. This initial study suggests that students treat dimensional analysis as a mere algebraic exercise, rarely invoking basic concepts such as the idea that only like units can be added.

AK02: 8:40-8:50 a.m. Developing a General Strategy for Selecting Coordinate Systems in Mechanics

Contributed – Thanh K. Le, University of Maine, 5709 Bennett Hall, Orono, ME 04469; thanh.le@maine.edu

Jonathan T. Shemwell, MacKenzie R. Stetzer, University of Maine

When solving mechanics problems, students often need to choose a coordinate system to analyze free-body diagrams and apply Newton's laws. Strategic rotation of the coordinate system can minimize the amount of mathematics required to solve for unknown forces. However, introductory physics students are usually not explicitly taught when and how to strategically rotate a coordinate system. Moreover, if they are introduced to a strategy, it is often just mentioned in passing. Thus, they may not understand why rotation can simplify the mathematics. As a result, students may develop a strategy based on the surface features of the problem (e.g., rotating coordinate systems for problems with inclined planes regardless of the forces involved). In this study, college students enrolled in a mechanics course completed an activity using contrasting cases to develop a general strategy for rotating coordinate systems for problems involving static situations. Preliminary data and emerging findings will be presented.

AK03: 8:50-9 a.m. Student Use of Metacognitive Gimmicks in Class and Lab

Contributed – Gary D. White, The George Washington Univ., 725 21st St, NW, Corcoran 104F, Washington , DC 20052; United States gwhite@gwu.edu

Tiffany-Rose Sikorski, Justin Landay, The George Washington Univ.

It has been documented that it is difficult to get even upper-level undergraduates to indulge in certain metacognitive behaviors (see "Upper-division Student Understanding of Coulomb's Law: Difficulties with Continuous Charge Distributions", by Bethany R. Wilcox, et al., for example). We have attempted to address this in part by separating the metacognitive bits from other problem solving barriers for students taking a junior level E&M class and an intermediate lab course. These students are regularly encouraged to check solutions to typical physics problems in the "usual three ways", namely: (1) checking that the units are appropriate, (2) discerning whether limiting cases match physical intuition, and (3) determining whether numerical values are consistent with benchmark values. We find that at least half of our students eventually engage in these metacognitive "gimmicks" over the course of the semester, even when not specifically prompted, and many continue to use them in subsequent classes.

AK04: 9-9:10 a.m. Nature of Students' Mathematical Difficulties and of Potentially Productive Remedies*

Contributed – David E. Meltzer, Arizona State University, 7271 E. Sonoran Arroyo Mall, Mesa, AZ 85212; david.meltzer@asu.edu

Matthew I. Jones, Arizona State University

We report on our continuing investigation of mathematical difficulties encountered by introductory physics students, and on our preliminary attempts to address these difficulties. We have previously documented high error rates on problems involving basic trigonometry, vector addition, and algebra, among students in both algebra-based and calculus-based introductory physics courses. We traced the difficulties to a combination of carelessness, insufficient practice, and conceptual misunderstandings. Through additional one-on-one interviews with students and continued analysis of students' responses on written diagnostics, we have attempted to clarify the relative contributions of these different factors, and to explore in more detail the nature of the careless errors and conceptual misunderstandings. Based in part on this work, we have begun development of instructional materials to help guide improved problem-solving performance. We will report on the current status of these various efforts.

*Supported in part by NSF DUE #1504986

AK05: 9:10-9:20 a.m. Synthesis Problems: Role of Mathematical Complexity on Student Mathematical Performance

Contributed – Bashirah Ibrahim, The Ohio State University, 231 Arps Hall, 1945 N. High Street, School of Teaching and Learning, Columbus, OH 43210-1172; bashirah2001@gmail.com

Lin Ding, The Ohio State University, School of Teaching and Learning

Andrew F. Heckler, Ryan Badeau, The Ohio State University, Department of Physics

We examined the effects of mathematical complexity on students' mathematical performance in solving synthesis physics problems. Here, mathematical complexity is operationally determined by the type of equations and the number of unknowns involved therein. Two types of synthesis problems, namely sequential and simultaneous, were investigated; each requiring either a consecutive or a concurrent application of multiple concepts. For the analysis, we focused on the following three levels (1) formulation of equations, (2) combination of equations, and (3) simplification of equations to obtain the final variable of interest. Results showed that in sequential synthesis problems, mathematical complexity negatively affected student performance on aspect (3). However, in simultaneous synthesis problems, mathematical complexity negatively affected student performance on all the three aspects. A possible explanation is that the type of synthesis problems may influence the ways students interpret the situations described in the problems, which in turn can influence their mathematical performance.

AK06: 9:20-9:30 a.m. Thinking Through the Model

Contributed – D. G. Sumith P. Doluweera, Georgia State University, Room 435A, 1 Park Place, Atlanta, GA 30303; ddoluweera@gsu.edu

Solving physics problems requires thinking through related models. This is not an easy task for a novice physics student. We typically teach students to think through models by discussing examples and doing problems in the class with students. This particular study is focused on Applications of Newton's laws and investigates if students correctly think through Newton's laws when they solve a related problem. Students' thinking is probed by giving a questionnaire before they begin solving a given problem. Answers to the questionnaire are analyzed, compare with problem solutions, and results are presented.

AK07: 9:30-9:40 a.m. Adapting Canonical Representations in Quantum Mechanics

Contributed – Erin Ronayne Sohr, University of Maryland College Park, Toll Building, College Park, MD 20740; erinsohr@gmail.com

Ayush Gupta University of Maryland College Park

Canonical representations in quantum mechanics represent toy models from which physicists build more complex systems. Previous research has focused on conceptual and mathematical difficulties students have when reasoning about these toy models. What is underexplored is how students adapt these toy models and representations when faced with new, potentially more complex, situations. We will present analysis of interviews with physics and engineering majors, showing some of the ways students manipulate, merge, break-down, and re-purpose these canonical representations and associated toy models. Our analysis utilizes a combination of discourse and interaction analysis methods in order to understand how the students and interviewer organize their material and social environments in problem-solving. We argue that students are capable of adapting these toy models, even while in the process of understanding the toy models themselves. The process of adaptation can also contribute towards deeper understanding of the toy models and associated canonical representations themselves.

AK08: 9:40-9:50 a.m. Instructor Approaches to Teaching Computation in Collaborative Physics Problem Solving

Contributed – Alanna S. Pawlak, Michigan State University. 567 Wilson Rd., East Lansing, MI 48824-1046; pawlakal@msu.edu

Paul W. Irving, Marcos D. Caballero, Michigan State University

An increasing emphasis is being placed on incorporating “authentic practices” into introductory physics courses, for example, through the inclusion of computational problems. Such problems can allow students to engage with the programming practices and numerical problem solving methods used by physicists. We conducted interviews with the instructors in a problem-based introductory mechanics course where students solved several computational problems. In these problems, students were provided minimally working programs in VPython that they had to modify in order to correctly model the physics of the situation in question. The instructors in this course come from a range of backgrounds, and include undergraduate learning assistants, graduate teaching assistants, and faculty from several subdisciplines of physics. We present preliminary analysis of these interviews suggesting that there are distinct ways that instructors may approach teaching computational problems in this environment.

AK09: 9:50-10 a.m. Infusing Numerical Differentiation and Analysis in Calculus-based Introductory Physics Laboratories

Contributed – Xiuping Tao, Winston-Salem State University, 601 S M L King Jr Dr., Winston Salem, NC 27110-0001; taoxi@wssu.edu

Recently the Joint Task Force on Undergraduate Physics Programs produced a report to provide guidance to physics departments to improve their students’ career readiness. The report, titled “Phys21: Preparing Physics Students for 21st-Century Careers,” states several findings in its summary. One finding is the broad consensus regarding needed skills and knowledge, including a wider and deeper knowledge of computational analysis tools. We report using Excel as a basic and most-accessible computational analysis tool in our calculus-based introductory physics laboratories. In our motion experiments, motion status is detected by a sensor working with a PASCO 750 USB Interface connected to a PC. The raw data are position vs. time, and the computer would further derive velocity vs. time and acceleration time vs. time. All data, raw or derived, are displayed in tables and graphs. We demonstrate hidden golden opportunities to learn numerical differentiation and data analysis skills most students lack.

Session AL: Topics in Diversity II

Location: CC - Breakout 10
Sponsor: AAPT
Date: Monday, July 24
Time: 8:30–9:30 a.m.

Presider: Troy Messina

AL01: 8:30-8:40 a.m. Equity, Inclusion, and Cookies: Addressing Physics Climate Through Diversity Discussions

Contributed – Katherine D. Rainey, CU Boulder, Department of Physics, Libby Drive, Boulder, CO 80305-5567; kara0871@colorado.edu

It is well known that women and people of color are largely underrepresented in physics at all levels, from undergraduates to faculty. A large body of literature has investigated the cause of this low representation; some work points to a “chilly” climate and unwelcoming culture within physics that is discouraging to women and people of color. In an effort to improve the culture within their department, a committee within the CU Boulder physics department has created Equity, Inclusion, and Cookies (EIC), a series of facilitated discussions and presentations related to diversity in physics open to everyone in the department (undergraduates, graduate students, postdocs, faculty, and staff). Here, we describe the EIC events to date, present initial reactions to these events from attendees, and discuss our plans for developing the series in the future.

AL02: 8:40-8:50 a.m. Characterizing Practices and Resources for Inclusive Physics Learning Environments*

*Contributed – Laura A. Wood,** Seattle Pacific University, 3307 3rd Ave., W, Seattle, WA 98119; woodl5@spu.edu*

Amy D. Robertson, Seattle Pacific University

Fostering inclusive physics learning environments is an important aspect of improving physics culture and teaching. In this project, we interviewed physics faculty who are actively working to make their classrooms and departments more inclusive. We characterized the inclusive practices these faculty described and the resources – e.g., the knowledge, dispositions, commitments, etc. – that fuel or support them. This talk will give examples of these resources and practices for inclusive physics learning, illustrating both the breadth and richness of resources physics faculty are using and the ways in which those resources are enacted in teaching strategies and departmental actions.

*This work is supported in part by NSF DUE 1611318.

**Sponsored by Amy D. Robertson

AL03: 8:50-9 a.m. Access Assemble! Bringing Together Student Leaders to Support Equity Programs

Contributed – Joel C. Corbo, University of Colorado Boulder, 860 35th St., Boulder, CO 80303; joel.corbo@colorado.edu

Chandra Turpen, University of Maryland College Park

The Access Network consists of six university-based programs from across the country working towards a more diverse, equitable, inclusive, and accessible STEM community. Each program places a strong emphasis on undergraduate and graduate student leadership, and some programs are entirely student-led. One component of Access is an annual Assembly, which brings together representatives from current and potential Access sites to update each other, share lessons learned, support each other in overcoming challenges, participate in professional development, and build relationships with others interested in promoting justice in STEM education. The Assembly is co-designed by a team of student leaders from each of the six Access sites in collaboration with network leaders. In this talk, we discuss the Assembly structure and development process, positive highlights and challenges that we encountered during our first Assembly, and lessons learned through post-Assembly surveys and the report of a taskforce that recommended changes to the Assembly.

AL04: 9-9:10 a.m. Investigating Attitudes and Performance of Students in Introductory Physics Courses: Gender Differences

Contributed – Timothy J. Nokes-Malach, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; nokes@pitt.edu*

Emily Marshman, Yasemin Kalender, Christian Schunn, Chandralekha Singh, University of Pittsburgh

Despite some efforts to encourage women to pursue majors from STEM disciplines, the percentage of women majoring in physics remains low. While much research has focused on gender differences in physics, relatively little is known about the differences between the attitudes of men and women and how these attitudes are related to performance outcomes in physics courses. We performed a longitudinal analysis of students in introductory physics courses by administering pre and post attitude surveys which assessed, e.g., their self-efficacy, grit, fascination with physics, and theory of intelligence. Pre and post conceptual tests were also administered to the students. The differences between the attitudes of men and women and the relationship between their attitudes and performance on conceptual surveys in physics was examined. Findings will be discussed.

*Sponsored by Chandralekha Singh

AL05: 9:10-9:20 a.m. Investigating Attitudes and Performance of Students in Introductory Physics Courses: Racial and Ethnic Minorities

Contributed – Yasemin Kalender, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; ZYK2@pitt.edu*

Emily Marshman, Tim Nokes-Malach, Chandralekha Singh, University of Pittsburgh

Despite some efforts to encourage students from underrepresented groups to pursue college study (especially in the STEM disciplines), the percentage of minority students majoring in physics remains low. Prior research has focused on the relationships between student performance, motivation, and retention in STEM disciplines. However, there is relatively little known about the attitudes of students from underrepresented racial or ethnic groups enrolled in physics courses. We performed a longitudinal analysis of students in introductory physics courses by administering pre and post attitude surveys which assessed, e.g., their self-efficacy, grit, fascination with physics, and theory of intelligence. Pre and post conceptual tests were also administered to the students. We examined the attitudes and performance outcomes of ethnic minorities in introductory physics courses. Findings will be discussed.

*Sponsored by Chandralekha Singh

AL06: 9:20-9:30 a.m. U.S. and Japanese Comparative Study of High School Physics Lessons

Contributed – Sachiko Tosa, Niigata University, Ikarashi-2-cho, 8050-banchi, Nishi-ku, Niigata, Niigata 950-2181 Japan; stosa@ed.niigata-u.ac.jp

How are Japanese High-School physics lessons different from U.S. lessons? In this study actual high school lessons in Japan (N=10) and U.S. (N=9) are analyzed and compared using RTOP (Reformed Teaching Observation Protocol). The preliminary results indicate that Japanese high-school lessons often do not include solid lesson structure in spite of the fact the importance of effective lesson design is well emphasized in elementary and middle-school science. The reason for this lack of effective lesson design can be traced in the abstractness of high-school physics content: teachers focus more on "what to teach" than "how to teach" The situation is different in the U.S. where the instructional approach is more divergent depending on the social and economic situation of the district. Cultural implications of the results are further discussed.

Awards Session

Location: CC - Event Center II
Date: Monday, July 24
Time: 10:30–11:30 a.m.

Presider: Janelle M. Bailey

Paul W. Zitzewitz Award for Excellence in K-12 Teaching: presented to J. Mark Schober, Trinity School, New York, NY

J. Mark Schober

Sharing Your Expertise

Approximately 27,000 people teach high school physics in the United States, and about a quarter of those are AAPT members. The rest? For many, physics is only one of several subjects they teach and nearly 60% of those teaching physics have degrees in fields other than physics or physics education. (www.aip.org/statistics) Such rich academic diversity needs a vibrant professional support community that is accessible, frequent, and relevant. A small fraction of teachers are able to attend and benefit from a national AAPT meeting — but what you take away from these conferences and develop in your classroom can be shared to increase access, develop relationships that provide ongoing support, and meet needs specific to your community. Your expertise is instrumental in building a strong community of physics teachers best able to serve their students. I've benefited from AAPT meetings and PTRA workshops and I've experienced vibrant professional learning communities through the St. Louis Area Physics Teachers, Modeling Instruction, and STEMteachersNYC. I will share some stories to help you identify and share your expertise, expanding AAPT's positive influence to the other 75% of high school physics teachers. The stakes are high — the future of science literacy, and physics' foundational role in scientific understanding, depends upon us.

David Halliday and Robert Resnick Undergraduate Physics Teaching Award: presented to Cindy Schwartz, Vassar College, Poughkeepsie, NY

Cindy Schwartz

What Can We Do in the Subatomic Zoo?

For over 30 years I have been teaching a course at Vassar, A Tour of the Subatomic Zoo. You see, I had to give it a catchy name as Vassar has no science requirements and early in my career as a particle physicist I wanted to give some science literacy to those who would otherwise leave without ever taking any science courses. One thing that came out of the course was my book A Tour of the Subatomic Zoo: A Guide to Particle Physics that just came out in a third edition. So what can you do? Many of us are not trained in particle physics but we can all go online these days and become overloaded with information about things like gravitational waves and Higgs bosons. But what can we do with our students once we are motivated to learn (or relearn) about the standard model and beyond. Since the audience that I had for this course was everything but physics majors, I needed to be very creative as the course developed over the years, so as they did not simply walk away with an overview of the last 100 plus years of physics and some of its applications in the real world. I wanted them vested! In this talk I will discuss two parts of the course that were unique and also could be used/adapted by many of you in both high school and college settings; the final project and the debate project. Initially their final project assignment was to write a short story or poem with subatomic particles as characters. There were so many good ones that I published them into a book Tales from the Subatomic Zoo. Then something happened! – Students who were music majors asked if they could write a song, art majors asked if they could create prints, pictures, drawings and even jewelry, then came the plays. I will show you my favorite play "Somewhere on a park bench in heaven" and my favorite song "I am a positron". The idea of the debate project came later on after the cancellation of the SSC in 1993. Each year, I would randomly select a location to build a new collider in the US. Students were assigned group roles and based on sound research could argue for or against the collider. They would make their arguments to a group of "senators" who volunteered. These senators were my colleagues from Vassar from departments such as economics, political science, geology, English etc. You get the idea! I will show some of the research presentations by the student groups which included local business owners and residents, an environmental impact group, taxpayer lobbyists, foreign and international physicists. Honestly, I never knew which way they would go but they were able to take their other Vassar interests and bring them to the table. I hope you come away from this talk with some creative ideas of your own about how you and your students won't get lost on the safari through the subatomic zoo.

TOP04: AIP Career Pathways Project

Location: CC- Breakout 9
Sponsor: AAPT/AIP
Date: Monday, July 24
Time: 12–1:30 p.m.

Presider: Robert Hilborn and Brad Conrad

This topical session focuses on the skills and tools needed to succeed as a physicist in the work place. Join us for an informational discussion focused on a few of the fundamental skills necessary in any career followed by a focus group looking into the tools and resources needed by students as they prepare for the workforce.

Session BA: Modeling Instruction at All Levels

Location: CC - Breakout 6
Sponsor: Committee on Physics in High Schools
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Kathy Harper

BA01: 1:30-2 p.m. Modeling From K-15? Considering a Hopeful STEM Educational Future

Invited – Jeffrey Hengesbach, American Modeling Teachers Association, 3043 W Juniper Ave., Phoenix, AZ 85053; jthengesbach@yahoo.com

Modeling Instruction (MI) began as a teaching method supporting high school physics in the early 1990's. The framework it provided substantively shifted the instructional focus from the teacher's presentation to the student's engagement in scientific process. Its success motivated continued developments over the past 25 years. Today, a student could begin learning science through MI in the 6th grade and continue through their college career. Modeling fades the boarders between science disciplines as foundational skills and key content knowledge strands are both remembered and reapplied to successive classes. This discussion will focus on how MI's start in the physics class has since expanded, the benefits and challenges to student's and teacher's experiences, and potential developments ahead.

BA02: 2-2:30 p.m. Reflections on 22 Years of Modeling Instruction with 9th Graders

Invited – Rex P. Rice, Clayton High School, 6051 Kingsbury Ave., St. Louis, MO 63112; rexrice@swbell.net

A course in physics has been taught to high school freshmen at Clayton High School since the early 1960s. In the early 1990's we changed the science curriculum and sequence to make an introductory course in physics for all freshmen, followed by chemistry for sophomores and biology for juniors. In 1995 the author of this paper was trained in Modeling Instruction, and began to transform the physics program based on Modeling methodology for his physics classes at the school. As of the early 2000's, all four physics instructors at the school had been trained in Modeling Instruction and each member of this team has been teaching physics to freshmen using Modeling Instruction ever since. This paper will highlight the path that led us to Modeling Instruction, the process of developing a ninth grade version of the Modeling instructional materials, and the successes of the program.

BA03: 2:30-3 p.m. A Modeler's Journey, or Why I Drank the Kool-Aid

Invited – Charles P. Deremer, Marion L. Steele High School, 450 Washington Street, Amherst, OH 44001; chas_deremer@amherstk12.org*

Maybe you feel that your students aren't grasping the material like they should. Maybe you feel like what you're doing in the classroom isn't working. You're working hard, but it just isn't working. That was me, too. This is my journey from a struggling novice teacher to becoming a modeler. Modeling saved my students' learning and it redeemed my career. My course enrollment tripled. My students objectively perform better than they ever had. This is how I went from there to here. You can get here, too.

*Sponsored by Dr. Kathy Harper

BA04: 3-3:30 p.m. Vocabulary and Experiences to Teach a Center of Mass Model

Invited – Michael E. Lerner, Beachwood High School, 25100 Fairmount Blvd., Beachwood, OH 44122; italojew@yahoo.com

Taylor Kaar, Laurel School, Shaker Heights, OH

Linda B. Pollack, Theodore Roosevelt High School, Kent, OH

Robert J. Engels, St. Vincent-St. Mary High School, Akron, OH

Teaching with a systems-focused approach is new to many teachers, as it was to us. We worked together to devise experiences and problems that deepened our practice of teaching open and closed systems. In this session, we will share the vocabulary and definitions that help our students understand systems. We will also demonstrate, and let you participate in, activities that build a model of how systems work and activities that allow students to use that understanding.

Session BB: Effective Practices for Integrating Computation in Undergraduate Physics

Location: CC - Ballroom D
Sponsor: Committee on Educational Technologies
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Larry Engelhardt

BB01: 1:30-2 p.m. Mapping the New AAPT Recommendations for Computational Physics into our Curriculum

Poster – Marie Lopez del Puerto, University of St. Thomas, 2115 Summit Ave., Saint Paul, MN 55105; mlpuerto@stthomas.edu

Marty E. Johnston, Gerry Ruch, Adam S. Green, Paul R. Ohmann, Jeff A. Jalkio, Richard A. Thomas, Michael P. Wood, University of St. Thomas

For the past 15 years, the University of St. Thomas physics department has been integrating computational physics throughout the undergraduate curriculum. We have incorporated real-world computational physics problems into upper-division physics courses, developed experiments that involve computational data collection and analysis for the sophomore-level experimental methods course, re-developed the sophomore-level modern physics course to serve as an introduction to computational physics, and established a new junior-level course that focuses exclusively on computational methods. By mapping our efforts to the suggested learning outcomes in the new AAPT Recommendations for Computational Physics in the Undergraduate Physics Curriculum, we assess our progress and find areas that we still need to address in our curriculum.

BB02: 1:30-2 p.m. Integrating Computation into Undergraduate Programs: Progress at Eastern Michigan University

Poster – Ernest Behringer, Eastern Michigan University, Department of Physics and Astronomy, Ypsilanti, MI 48197; ebehringe@emich.edu

David Pawlowski, Marshall Thomsen, Eastern Michigan University

The Department of Physics and Astronomy at Eastern Michigan University has recognized that computational physics knowledge and skills are essential for our undergraduate students. We have developed and piloted two computational physics courses that will be required for our undergraduate physics programs beginning in fall 2017. The first course covers foundational techniques and is required during the introductory course. The second course covers techniques applicable to the upper-level core courses and is a prerequisite for the required capstone project course. We will describe the context and the content of these courses and our ongoing efforts to integrate computation into our core courses as well as upper-level laboratory courses.

BB03: 1:30-2 p.m. Methods of Computational Physics at the University of St. Thomas

Poster – Gerald T. Ruch, University of St. Thomas, 2115 Summit Ave., St. Paul, MN 55105; gtruch@stthomas.edu

The University of St. Thomas Physics department has been working to integrate computational physics throughout our undergraduate physics curriculum. In addition to the inclusion of computational exercises in existing courses, we have created a standalone course titled Methods of Computational Physics. Rather than presenting a loosely coupled collection of computational techniques, our course strives to teach our students how to tackle a large scale computational problem. The numerical and computational techniques required to solve the problem are explored along the way and fit piece by piece into a larger software framework. In this way, the students learn not only the specific techniques but how to break a large problem into its component parts and how to create, maintain, and expand a large piece of scientific software.

BB04: 1:30-2 p.m. P^3: A Practice Focused Learning Environment

Poster – Paul W. Irving, Michigan State University, 1310D Biomedical and Physical Sciences, Building, East Lansing, MI 48823; paul.w.irving@gmail.com

Michael J. Obsniuk, Marcos D. Caballero, Michigan State University

There has been an increased focus on the integration of practices into physics curricula, with a particular emphasis on integrating computation into the undergraduate curriculum of scientists and engineers. In this paper, we present a university-level, introductory physics course for science and engineering majors at Michigan State University (MSU) called P^3 (Projects and Practices in Physics) that is centered around providing introductory physics students with the opportunity to appropriate various science and engineering practices. The P^3 design integrates computation with analytical problem solving and is built upon a curriculum foundation of problem-based learning, the principles of constructive alignment and the theoretical framework of community of practice. The design includes an innovative approach to computational physics instruction, instructional scaffolds, and a unique approach to assessment that enables instructors to guide students in the development of the practices of a physicist. We present the very positive student related outcomes of the design gathered via attitudinal and conceptual inventories and research interviews of students' reflecting on their experiences in the P^3 classroom.

BB05: 1:30-2 p.m. Relaxation Method Modeling of Non-ideal Parallel Plate Capacitor

Poster – Sean P. Bartz, Macalester College, 1600 Grand Ave., Saint Paul, MN 55105-1801; sbartz@macalester.edu

This computational exercise is part of a lab activity for an upper-level majors course in electrodynamics. In the laboratory portion of the exercise, students take measurements that allow them to calculate the capacitance of a large parallel-plate capacitor of varying aspect ratio. In the computational part of the exercise, students learn to use the relaxation method to solve Laplace's equation for the potential of various systems. Using their results, they can compare to their measurements and the calculation for an idealized infinite capacitor. MATLAB software was used for the computational component. We will show results from the first implementation of this lab exercise and possible future improvements.

BB06: 2-2:10 p.m. PICUP Framework for Integrating Computation into Undergraduate Physics Courses

Invited – Kelly R. Roos, Bradley University, 1501 West Bradley Avenue, Peoria, IL 61625; rooster@bradley.edu

The Partnership for Integration of Computation into Undergraduate Physics (PICUP), an informal group of physics faculty from around the country, is committed to building a community of STEM educators dedicated to integrating computation into the undergraduate curriculum. PICUP seeks to impact the undergraduate physics curriculum by facilitating the inclusion of computer-based, algorithmic problem solving in such a way that it plays a role that is as important as non-computational mathematics. Such computational inclusion can providing a deeper conceptual understanding of physical principles, and enhance students' problem-solving abilities. In this presentation, I shall describe the framework behind PICUP's unique educational materials development effort.

BB07: 2:10-2:20 p.m. Our Department Journey Towards Computational Competency

Invited – Marty Johnston, University of St. Thomas, OWS 153, 2115 Summit Ave., Saint Paul, MN 55105; mejohnston@stthomas.edu

In this talk I will describe the process of curricular revision at the University of St. Thomas, an averaged sized bachelor degree granting program. For over a decade we have been working to infuse computational skills throughout our curriculum. As our understanding of physics education evolves, our curriculum changes with it. It has been a slow but steady process involving the entire department – experts and non-experts alike. By building a holistic vision for our program and making it a departmental effort we have made lasting changes to our curriculum.

BB08: 2:20-2:30 p.m. Integrating Computational Activities Vertically into the Physics Curriculum

Invited – Jay Wang, Physics, UMass Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747-2300; jwang@umassd.edu

Students benefit from computation in the classroom in multiple ways, including better understanding through hands-on engagement, solving more realistic problems, learning deeper insight via model building, increasing computational thinking, and gaining a central skill set for careers recommended in the Phys21 report. In this panel presentation we describe vertical integration of computational modeling activities into physics courses from introductory to graduate levels. We discuss specific examples from all core areas of physics such as projectile motion with drag, planetary simulations, electromagnetics and waves, Boltzmann distribution and Brownian motion, visualizing quantum mechanics, and so on (see http://www.faculty.umassd.edu/j.wang/ for select examples). These examples can be used as actual projects or as ready-to-use demos in the classroom. They are given in Jupyter notebook format, but can be adapted to any programming environment. For active participation, please bring your own device with Python, Jupyter (and optionally VPython) installed (see installation instructions at above link).

BB09: 2:30-3 p.m. Using Jupyter Notebooks and GitHub Classroom for Upper-Level Physics

Poster – Marcos D. Caballero, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824; caballero@pa.msu.edu

Computation is a practice that is increasingly important for physics majors to learn. In addition, modern computational practice makes use of tools such as version control (i.e., GitHub). In this poster, we present a practical approach to using Jupyter notebooks and GitHub in an upper-level course for physics majors—a course in which few students have any prior experience in computation. Highlighted are the use of scaffolded Jupyter notebooks and GitHub classroom—a tool for distributing and collecting student work using git repositories.

BB10: 2:30-3 p.m. AAPT Recommendations for Computational Physics in the Undergraduate Physics Curriculum*

Poster – Ernest R. Behringer, Eastern Michigan University, Department of

Physics and Astronomy, Ypsilanti, MI 48197; ebehringe@emich.edu

Because computation is ubiquitous in the practice of physics, curricula that are authentic to the discipline include opportunities to develop and practice computational skills in the context of constructing and testing models of physical phenomena. This is the basis for the 2011 AAPT statement on computational physics urging "every physics and astronomy department [to] provide its majors and potential majors with appropriate instruction in computational physics." The AAPT Undergraduate Curriculum Task Force (UCTF) developed a set of recommendations for including computational physics skills and practices in the undergraduate physics curriculum, approved in October 2016, and these recommendations will be described briefly here. Information about current implementations of computational physics instruction will also be presented.*Submitted on behalf of all AAPT UCTF members.

BB11: 2:30-3 p.m. Enhanced Undergraduate Physics Education Through Computation

Poster – Kelly Roos, Bradley University, 1501 West Bradley Avenue, 408 Jobst Hall, Peoria, IL 61625; rooster@bradley.edu

In this poster I will present examples of typical undergraduate physics topics that can be more effectively presented and learned in a computational mode, than with a purely analytical, non-computational approach.

BB12: 2:30-3 p.m. Enhancing Student Learning with Computational Modeling

Poster – Jay J. Wang, Physics, UMass Dartmouth, 285 Old Westport Rd., North Dartmouth, MA 02747-2300; jwang@umassd.edu

Following the panel presentation we discuss problem-specific activities in computational modeling that can be integrated into any physics course to engage students in the understanding of a given topic. We will describe how one can begin with simple problems like 1D free fall, compute it numerically and build a template. We can then add some realism and complexity into it such as by modeling air resistance, and turn it into 3D realistic projectile motion. With a general template in place, students can be guided through the same process to explore more advanced problems including damped harmonic oscillator, vibration and waves, interactions of charged particles and Rutherford scattering, route to thermal equilibrium, and quantum wave propagation, etc. The basic computational environment is Python in Jupyter, but the examples should be easily adaptable to other environments such as GlowScript and trinket. To try it in real time, please bring your own laptop with Python, Jupyter (and optionally VPython) installed with packages like Anaconda or Canopy. Please see http://www.faculty.umassd.edu/j.wang/ for examples and installation instruction.

BB13: 2:30-3 p.m. Computational Physics at Francis Marion University

Poster – Jordan D. McDonnell, Francis Marion University, 4822 E Palmetto St., Florence, SC 29501; jmcdonnell@fmarion.edu

Larry Engelhardt Francis Marion University

We overview the activities in computational physics at Francis Marion University. Our sequence of computational physics courses begins with an introduction to computational methods and their application to physical problems, and culminates with a variety of advanced methods including an introduction to high performance computing. We also highlight the use of computational methods in our other physics courses, including electricity and magnetism, statistical mechanics, and quantum mechanics.

Session BC: Panel – Coping Mechanisms for Physics Students from Underrepresented Groups

Location: Marriott - Covington Ballroom I
Sponsor: Committee on Diversity in Physics
Co-Sponsor: Committee on International Physics Education
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Simone Hyater-Adams

This session focuses on methods for thriving as a marginalized student in physics. This will be an alternative session that involves discussion with a panel as well as amongst attendees. There will also be a speaker who does research on the common experiences of underrepresented students in STEM in order to frame the panel and discussion. There will be a panel of students discussing their experiences in the field, and coping methods they used when facing hurdles, and an activity that encourages attendees to come up with a toolkit of methods to cope with the hurdles they, or their students may be facing.

Panelists:

Alexis Papak, University of Maryland, College Park

Kali Johnson, Arizona State University

Charles Ramey, Texas Tech University

Katherine Rainey, University of Colorado, Boulder

Session BD: Panel on First Year Teacher Concerns

Location: Marriott - Covington Ballroom II
Sponsor: Committee on Professional Concerns
Co-Sponsor: Committee on Teacher Preparation
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Bradley Gearhart

This panel will examine the concerns and challenges of first-year physics teachers and highlight recommendations to the larger physics education community to provide necessary support to new teachers, to enable their induction into the profession, and to encourage their engagement with the physics teaching community.

Panelists:

Kelli Gamez Warble, Arizona State University, Tempe

Steve Lance, Democracy Prep Public Schools

Earl Legleiter, Englewood, CO

Session BE: Climate Change

Location: CC - Breakout 5
Sponsor: Committee on Science Education for the Public
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Michael Gallis

BE01: 1:30-2 p.m. Climate and Energy Education for Physical Science and Physics Classrooms

Invited – Jason Cervenec, Byrd Polar and Climate Research Center - The Ohio State University, 1090 Carmack Road, Columbus, OH 43210; cervenec.1@osu.edu

Global climate change is a wicked problem. By taking part in our everyday activities, each of us emits a gas called carbon dioxide that spreads far from its source, impacting the lives of others for hundreds to thousands of years. Carbon dioxide in the atmosphere is now more abundant than it has been in 3 million years, causing a panoply of environmental impacts. World governments have agreed to adopt energy policies to keep temperature increases below 2 degrees Celsius, but reaching such a target is becoming increasingly difficult. While often seen as belonging in the Earth sciences, which few students study beyond middle school, climate and energy literacy require content knowledge from biology, chemistry, and physics in addition to understanding the nature of science and argumentation. Many ways to strengthen both climate and energy literacy within physical science and physics classrooms will be presented.

BE02: 2-2:30 p.m. What Glaciers Really Tell Us About Climate Change?

Invited – Umesh Haritashya, University of Dayton, 300 College Park, Dayton, OH 45458; uharitashya1@udayton.edu

Glaciers play a major role in our Earth system. Looking back at many years of Earth's existence ice ages have had massive impact in shaping our modern history and mesmerizing landscape. However, the last few decades have provided us a different reality where glaciers are retreating faster than ever and contributing heavily to the sea level rise. Although glaciers contain environmental history from many thousands of years, they also serve as a climatic marker and most visible evidence by responding directly to the climate change. Fortunately, they are much sturdier than ice cubes which melt fast when introduced to a warmer environment. Glaciers do not melt slowly, but when they start to melt and break down they generally represent major underlying issues. This presentation will highlight these issues and reflect on glacier sensitivity and its complex relationship with topography, glacier hydrological network, and climate system coupling involving the westerlies, the monsoon, the ocean circulations, and so forth.

BE03: 2:30-3 p.m. Effectively Scaffolding Critical Thinking About Politicized Science

Invited – Erin P. Hennes, Purdue University, 703 Third Street, West Lafayette, IN 47907; ehennes@purdue.edu

As climate change has become politicized in the U.S. and around the world, physics educators have been confronted with the need to develop strategies for not only effectively teaching the science but addressing the unique psychological factors that lead to heightened skepticism in this domain. Information deficit models predict that education should increase acceptance of climate science, yet a large body of work demonstrates that education is ineffective in reducing skepticism and can even increase it. We take a social psychological approach to examining the motivations that underlie resistance to climate change information and how these motivations bias how scientific information is processed. We discuss strategies for addressing these motivations in the classroom in order to facilitate objective and accurate scientific information processing. Finally, we provide suggestions for scaffolding critical thinking about scientific evidence in order to empower the public to critically evaluate the evidence of anthropogenic climate change themselves.

BE04: 3-3:10 p.m. Physics of Clouds

Contributed – Celia Chung Chow, CCSU, 9 Andrew Drive, Weatogue, CT 06089; cchungchow@comcast.net

Facing the global weather changes so drastically, one needs to find basic roots to understand the changes. The basic changes come from the variations in cloud formation, pressure, and temperature, etc. it is hard to put specific equations to describe these complex phenomenons. Yet, one can refer to tables, diagrams, plus some analytical equations to obtain more understanding. Hopefully, one can cope with our changing weather with deeper understanding.

BE05: 3:10-3:20 p.m. Using Climate Data to Teach Statistics

Contributed – Joseph F. Kozminski, Lewis University, Department of Physics, One University Pkwy., Romeoville, IL 60446; kozminjo@lewisu.edu

In this age of big data, sets of climate data are easily obtainable and freely available for use in the classroom or lab. Students seem to find working with real data more appealing than using toy data sets when learning statistics, and the wealth of climate data available is an especially valuable resource. It can be used for teaching basic statistics like mean and standard deviation to teaching more advanced topics like least squares fitting and correlations. These data are also useful for teaching various plotting techniques. Moreover, there is a positive social impact in using these data. When students are able to generate the climate plots they see in the news from these large datasets or to calculate the correlation coefficient between carbon dioxide emissions and average global temperature, for example, there is the opportunity for good conversation about climate disruption to arise.

BE06: 3:10-3:20 p.m. Climate Science Across the Liberal Arts Curriculum at Gustavus Adolphus College

Contributed – Charles Niederriter, Gustavus Adolphus College, 800 West College Ave., Saint Peter, MN 56082; chuck@gustavus.edu

Julie Bartley, Thomas Huber, James Dontje, Jeff Jeremiason, Gustavus Adolphus College

At Gustavus Adolphus College, the Climate Science Project aims to help non-geoscience faculty introduce climate science content in their courses in order to increase climate science literacy among students. We assembled an interdisciplinary team of faculty with climate science expertise to develop climate science modules for use in non-geoscience courses. Faculty from the social sciences, humanities, arts, education, and natural sciences attended workshops in which they developed plans to include climate science in their courses. Based on these workshops, members of the development team created short modules for use by participating faculty that introduce climate science concepts to a non-specialist audience. The Climate Science Project at Gustavus Adolphus College aims to increase climate science literacy in both faculty members and students by creating accessible climate science content and supporting non-specialist faculty in learning key climate science concepts. In this way, climate science becomes embedded in current course offerings, including non-science courses.

Session BF: Preparing the Community for the August 21st Solar Eclipse

Location: CC - Breakout 4
Sponsor: Committee on Space Science and Astronomy
Co-Sponsor: Committee on Science Education for the Public
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Toby Dittrich

BF01: 1:30-2 p.m. The Citizen CATE Experiment for the 2017 Total Solar Eclipse

Invited – Matt Penn, National Solar Observatory, 950 N Cherry Ave., Tucson, AZ 85719; mpenn@nso.edu*

Robert Baer, Southern Illinois University Carbondale

Richard Gelderman, Western Kentucky University

Michael Pierce, University of Wyoming

Donald Walter, South Carolina State University

The inner regions of the solar corona from 1–2.5 Rsun are poorly sampled both from the ground and space telescopes. A solar eclipse reduces the sky scattered background intensity by a factor of about 10,000 and opens a window to view this region directly. The goal of the Citizen Continental-America Telescopic Eclipse (CATE) Experiment is to take a 90-minute time sequence of calibrated white-light images of this coronal region using 60 identical telescopes spread from Oregon to South Carolina during the 2017 August 21 total solar eclipse. Images from the CATE network will characterize velocities, accelerations and density enhancements in solar polar plumes and study plasma instabilities in prominences and their interaction with the hot corona. After the eclipse, the CATE equipment will be kept by the volunteers and used for observations of the Sun, variable stars, and comets in follow-up citizen science programs.

*Invited by Toby Dittrich

BF02: 2-2:30 p.m. Preparing for The Great American Total Solar Eclipse of Aug. 21, 2017

Invited – Douglas Duncan, Univ. of Colorado, UCB 391, Boulder, CO 80309; dduncan@colorado.edu

Prepare yourself, your school, your community for the first total solar eclipse to cross the continental U.S. since 1979! Should you travel to the path of totality? (Absolutely! Even a 99% partial eclipse is NOTHING like a total eclipse) Where should you go? How should you prepare? What national efforts can you tap into? Where can you find detailed maps and other resources? Included will be a video from a previous eclipse that captures the excitement better than anything else I know. The video is R-rated for language… you will not see it on TV—because a total ellipse looks like the end of the world and people respond intensely. Learn how to help people view safely and make significant money as a fundraiser.

BF03: 2:30-3:30 p.m. Modern Eddington Experiment

Poster – William A. Dittrich, Portland Community College, PO Box19000, Portland, OR 97219; tdittric@pcc.edu

The modern Eddington experiment will be performed during the August 21, 2017 eclipse. This poster describes the new method used to drastically improve the accuracy of this historic experiment.

BF04: 2:30-3:30 p.m. Preparing Ada Oklahoma for the 2017 Solar Eclipse

Poster– Carl T. Rutledge, East Central University, 1100 East 14th Street, Ada, OK 74820; crutledge@mac.com

Plans for preparing East Central University and the Ada, OK, community for the 2017 solar eclipse will be presented. Experiences in viewing solar eclipses in Perry, FL, in 1970 and Cap Chat, Quebec, Canada, in 1972 will also be described.

BF05: 2:30-3:30 p.m. Stratospheric Temperature Changes Monitored During a Solar Eclipse Using Balloons

Poster – Kaye L. Smith, St. Catherine University, 2004 Randolph Ave., St. Paul, MN 55105; klsmith2@stkate.edu

James Flaten, University of Minnesota, Twin Cities

Erick Agrimson, St. Catherine University

St. Catherine University and the University of Minnesota Twin Cities have studied the thermal wake effect of an ascending high altitude balloon (HAB). A thermal wake occurs when a HAB influences and changes the surrounding ambient atmospheric temperature of the air through which it passes. During daytime flights, the thermal wake is warmer than the surrounding air but during nighttime flights there is an opposite effect, a cooling of the atmosphere surrounding the balloon. We have developed a "wake boom" to characterize the magnitude and extent of the thermal wake below an ascending balloon. The solar obscuration during the total solar eclipse of 8/21/2017 will provide a unique opportunity to monitor temperature changes of the stratosphere within and outside the wake, as solar heating effects will be mitigated for a short time. Temperature measurements will be collected during stratospheric flights with weather balloons before, during, and after the eclipse event.

BF06: 2:30-3:30 p.m. The Citadel Observes Solar Eclipse Leaving the North American Continent

Poster – Joel C. Berlinghieri, The Citadel, 171 Moultrie, Charleston, SC 29409; berlinghieri@citadel.edu

Patrick R. Briggs, Russell O. Hilleke, Mikhail M. Agrest, Jim Near, The Citadel

The Citadel in Charleston, SC, will host student and community informational seminars and workshops during the week before the North American Solar Eclipse visits our area as it passes out to sea. Observations, recordings, and environmental measurements will be made at three sites: The Citadel campus in downtown Charleston, The Citadel Beach House on the Isle of Palms (northeast of the campus), and just south of McClellanville at a point near maximum totality. In addition to our college students, faculty, and staff and in cooperation with the Charleston County School District, safe viewing will be provided for area students and the general public.

BF07: 2:30-3:30 p.m. Regener-Pfotzer Maximum Changes Occurring During a Total Solar Eclipse

Poster – Erick Agrimson, St. Catherine University, 2004 Randolph Ave, #4105, Saint Paul, MN 55117l epagrimson@stkate.edu

Gordon McIntosh, University of Minnesota, Morris

James Flaten, University of Minnesota, Twin Cities

Kaye L. Smith, St. Catherine University

The University of Minnesota, Morris and St. Catherine University have used Geiger counters to study the cosmic ray flux during high altitude balloon (HAB) flights. We have measured the omnidirectional cosmic ray flux, plus coincidences between pairs of Geiger counters mounted both vertically and horizontally. Pressure, temperature, and 3D location of balloon payloads are also logged. The "horizontal coincidence" flux indicates the presence of cosmic ray showers, with multiple particles generated from one initial interaction. All fluxes grow with increasing altitude until the Regener-Pfotzer (RP) maximum. These fluxes provide a means to study the structure of cosmic ray air showers as a function of altitude. The total solar eclipse of 8/21/2017 will provide a unique opportunity to see how changes in the (RP) maximum and ionization rates are influenced by temporary solar obscuration. Flux measurements will be collected before, during, and after the eclipse event.

BF08: 2:30-3:30 p.m. Celebrating the 2017 Eclipse With Anyone Who Will Listen

Poster – Richard Gelderman, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu

Theo Wellington, Western Kentucky University

Western Kentucky University's football stadium will host 20,000 K-12 students for the 2017 August 21 total solar eclipse. That is the first day of class for WKU, and all of the students, staff, and faculty are invited to join a massive party in the middle of our beautiful campus. The day before the eclipse a community-based science festival will take place in downtown Bowling Green, culminating with a show at the local minor league ballpark demonstrating the science of fireworks. All of this required intensive efforts at communicating with government officials, media representatives, school administrators, civic organizations, and the general public.

BF09: 2:30-3:30 p.m. Common Struggles in Understanding Eclipses: Research and Tools from Temple/AAPT

Poster – Ramon E. Lopez, University of Texas at Arlington, One Physics Ellipse, College Park, MD 20740; rvieyra@aapt.org

Bradley S. Ambrose, Grand Valley State University

Janelle M. Bailey, Temple University

Ximena C. Cid, California State University

Shannon D. Willoughby, Montana State University

Temple University, in coordination with the AAPT as a part of the NASA Heliophysics Education Consortium, has built a task force to develop astronomy and heliophysics resources for introductory and advanced astronomy and physics learning in higher education institutions (including for pre-service teacher education programs). Outcomes of research will be shared, including student performance on a pre/post eclipse concept survey, concept questions, lab activities, lecture tutorials, and homework assignments. See aapt.org/resources/eclipse2017 for access to the resources developed by this team.

BF10: 2:30-3:30 p.m. Experience the 2017 Eclipse Across America Through NASA's Eyes

Poster – Carolyn Ng, ADNET Systems Inc./NASA GSFC, 8800 Greenbelt Road, Code 672, Greenbelt, MD 20771; carolyn.y.ng@nasa.gov

Louis A. Mayo, Troy D. Cline, ADNET SYSTEMS INC/NASA GSFC

Alex Young, NASA GSFC*

Sten Odenwald, Astronomy Cafe

Join NASA and millions in the U.S. and around the world in observing the August 21, 2017 solar eclipse. This presentation will discuss NASA's plans for the 2017 eclipse, highlighting some programs, resources, and citizen science activities that will engage and educate many across the country and beyond. NASA will offer unique observations of this celestial event from the ground to space. Additionally, there are do-it-yourself (DIY) science, lunar and math challenges, art projects, Makerspace ideas, and various activities for learners of all ages. Education resources and tool kits may be useful for education and public engagement. Find out what events are happening in your neighborhood, and plan your own eclipse parties with resources and activities. Last but not the least, experience the eclipse on August 21 and learn more through NASA broadcast programming that will include telescopic views from multiple locations, simple measurements, and live and taped interviews.

*Dr. C. Alex Young is the Principal Investigator of the Heliophysics Education Consortium, of which AAPT is a partner, involving Ms. Rebecca Vieyra et. al.

Session BG: The Physics of the NSF IUSE Program

Location: CC - Breakout 7
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Kevin Lee

BG01: 1:30-2 p.m. IUSE Unleashes Synergy: The Interlocking Stories of Three Proposals*

Invited – Norman Chonacky, Yale University. 36 Lincoln St., New Haven, CT 06511; norman.chonacky@yale.edu

David Winch, Kalamazoo College - emeritus

Kelly Roos, Bradley University

Three awards culminated a decade of preparatory research and experimentation (1) done by a dozen physicists driven by a shared conviction: "Computation is as much an integral method for understanding physics as for doing physics." The IUSE program has finally permitted us to launch a national effort to continue this work in the context of our developing the competence and confidence of undergraduate physics faculty to gradually address this goal. It is sweeping because its antecedents are intertwined and any credible effort to address them must be pursued synchronously as much as possible. One solution would be to present them all in a single proposal. Given the constraints that previous NSF DUE programs imposed, our task faced high barriers to an award. What IUSE offered us was the possibility to parse the entanglement in this "Gordian Knot" using characteristics it invites - organizational flexibility; canonical challenge; innovative thinking - synergistically.

* This work supported in part by the National Science Foundation awards - 1432363, 1505278, and 1524963. 1. Chonacky, N. and D. Winch (2008). "Integrating computation into the undergraduate curriculum: A vision and guidelines for future development." American Journal of Physics 76(4&5): 327-333

BG02: 2-2:30 p.m. Faculty Images of Equity and Inclusion in Physics*

Invited – Rachel E. Scherr, Seattle Pacific University, 3307 Third Avenue West, Seattle, WA 98119; rescherr@gmail.com

Tali Hairston, Amy D. Robertson, Abigail R. Daane, Seattle Pacific University

Arlene M. Knowles, American Physical Society

Physics faculty have knowledge, beliefs, values, and priorities about equity that can support (or undermine) best practices for inclusive physics learning environments. Using interviews and focus group discussions, we are learning how faculty understand the work of equity and inclusion in physics. Initial observations suggest that faculty have a variety of images of equity in physics, and that different discussion prompts elicit different images. Some faculty images suggest a deficit model, in which members of underrepresented groups are seen as lacking experiences or resources that they need to succeed. Others are positive images about improving the culture of physics and rectifying injustice. Many faculty see a connection between equity work and active learning strategies. We take the perspective that positive images of equity work will be an effective basis for the development of resources to support faculty in creating inclusive physics learning environments.

*This material is based upon work supported by National Science Foundation Grant No. 1611318.

BG03: 2:30-3 p.m. Addressing Dissemination: An Example from the C3PO Project*

Invited – Evan Frodermann, University of Minnesota, Minneapolis, MN 55455

Leonardo Hsu, Missouri State University

Ken Heller, Emily Smith, Jie Yang, University of Minnesota

When creating materials that can impact the practice of education, it is insufficient to simply "build a better mousetrap." Research indicates that instructors perceive the need to modify resources developed by others to take into account their beliefs and values, their constraints, and the needs of their students. Difficulties in making such modifications can inhibit adoption of those materials. A second issue is that when instructors adopt tools or curricula, they usually do modify them, even if those modifications violate the primary principles of the materials and make them less effective. We see the task of developing materials as navigating between this Scylla and Charybdis. The goal of the C3PO project is to explore this navigation in the context of a software tool that enhances students' problem-solving experience within existing instructional environments.

*This work was partially supported by NSF DUE-1504649 and by the University of Minnesota.

BG04: 3-3:30 p.m. Promoting Innovation and Entrepreneurship in Physics: The PIPELINE Network*

Invited – Crystal Bailey, American Physical Society, One Physics Ellipse, College Park, MD 20740; bailey@aps.org

There has been a recent groundswell of interest among physics educators in teaching innovation and entrepreneurship within physics, as more attention is being paid to the future career preparedness of physics graduates. There is evidence to support that adding workforce-relevant learning to the physics discipline could not only enhance physics students' career preparedness and workforce confidence, but could also attract a larger and more diverse pool of physics majors. The NSF-funded PIPELINE project brings together efforts of six institutions to create and document new approaches to teaching innovation and entrepreneurship in physics which will be shared with the broader community. The project will also advance our understanding of how these practices affect student and faculty attitudes towards innovation and entrepreneurship in physics. In this talk, I will provide updates on the progress of this project in Year 1 of its implementation.

*Partial support for this work was provided by the National Science Foundation's Improving Undergraduate STEM Education (IUSE) program under Award No. 1624882.

Session BH: Impact and Reflections on the 20+ Years of TYC Physics Workshop Projects

Location: CC - Breakout 8
Sponsor: Committee on Physics in Two-Year Colleges
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Trina Cannon

BH01: 1:30-2 p.m. Physics Workshops for the 21st Century Project

Invited – Thomas O'Kuma, Lee College, P. O. Box 818, Baytown, TX 77522-0818; tokuma@lee.edu

From 1991 to 2016, there was a series of nine National Science Foundation Division of Undergraduate Education sponsored projects known as the Physics Workshops for the 21st Century Project. This project provided a series of faculty professional development workshops and conferences for high school and two-year college faculty who teach the core physics courses for technology and other programs. These workshops/conferences covered many of the major developments in teaching and learning strategies that have emerged in the last thirty years. In this talk, I will mention some of the many outcomes and teaching/program impacts that resulted from the over 100 workshops/conferences and many ancillary projects conducted during this endeavor.

BH02: 2-2:30 p.m. Reflections on TYC Workshop Project: Why I Am

Invited – Dwain Desbien, Estrella Mountain CC, 3000 N Dysart Rd., Avondale, AZ 85392; dwain.desbien@emcmail.maricopa.edu

I will be sharing how the TYC workshop project has helped shape me, my teaching, and my professional career. In addition other workshop attendees will be sharing their experiences and thoughts about this 20+ year project. If you attended any of the TYC Workshop Projects directed by Curt Hieggelke, Tom Okuma and Dwain Desbien, we invite you to come and share your thoughts and experiences as we reflect on the multiple individual instructional impacts and the larger TYC and PER impacts the project has had during its tenure.

BH03: 2-3 p.m. TYC Physics Workshop Projects Impact and Reflections

Invited – Todd R. Leif, Cloud County Community College, 2221 Campus Drive, Concordia, KS 66901; tleif@cloud.edu

I will be sharing how the TYC workshop project has helped shape me, my teaching and my professional career. In addition other workshop attendees will be sharing their experiences and thoughts about this 20+ year project. If you attended any of the TYC Workshop Projects directed by Curt Hieggelke, Tom O'kuma and Dwain Desbien, we invite you to come and share your thoughts and experiences as we reflect on the multiple individual instructional impacts and the larger TYC and PER impacts the project has had during its tenure.

BH04: 3-3:30 p.m. Impact of TYC Physics Workshop Project on Instruction and PER

Invited – Krista E. Wood, University of Cincinnati Blue Ash College, 9555 Plainfield Rd., Cincinnati, OH 45236; Krista.Wood@uc.edu

I will be sharing how the TYC Workshop Project has helped shape me, my teaching and my professional career. In addition, other workshop attendees will be sharing their experiences and thoughts about this 20+ year project. If you attended any of the TYC Workshop Projects directed by Curt Hieggelke, Tom O'Kuma, and Dwain Desbien, we invite you to come and share your thoughts and experiences as we reflect on the multiple individual instructional impacts and the larger TYC and PER impacts the project has had during its tenure.

Session BI: PER: Evaluating Instructional Strategies

Location: CC - Ballroom C
Sponsor: AAPT
Date: Monday, July 24
Time: 1:30–3:20 p.m.

Presider: Mary Kustusch

BI01: 1:30-1:40 p.m. Examining Student Attitudes via the Math Attitude and Expectations Survey

Contributed – Deborah Hemingway, University of Maryland, College Park, 3103 River Bend Ct #A101, Laurel, MD 20724; deb.hemingway@gmail.com

Mark Eichenlaub, Edward F. Redish, University of Maryland, College Park

The Math Attitude and Expectations Survey (MAX) is one of two novel assessment surveys developed as part of a mixed-methods exploratory project that seeks to understand and overcome the barriers that students face when using math in science. The MAX is a 30-question Likert-scale survey that focuses on student attitudes towards using mathematics in a reformed Introductory Physics for the Life Sciences (IPLS) course, part of the National Experiment in Undergraduate Education (NEXUS/Physics) project. Survey development and results are discussed with specific attention given to students' attitudes towards math and physics, opinions about interdisciplinarity, and the usefulness of physics in academic settings as well as in professional biological research and modern medicine settings. We also utilized the outcomes of the second novel assessment survey, the Mathematical Epistemic Games Survey (MEGS), to gain further insight into and compare results of this survey across multiple institutions.

BI02: 1:40-1:50 p.m. Controlling for the Effectiveness of Time Use in Physics Students

Contributed – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; stdevore@mail.wvu.edu

John Stewart, West Virginia University

Student time use is a major element of success in any course, especially in physics courses in which expertise is earned largely through exposure to the problem-solving process. Surveys were developed to probe the distribution of student time use across various typical tasks associated with the introductory, calculus-based physics sequence. Preliminary results controlling for student ability using SAT/ACT scores showed limited correlation between time use and student success. Additional surveys were developed and implemented to measure other factors including modified subscales from the Motivated Strategies for Learning Questionnaire. The effectiveness of time use at predicting student success when controlling for these factors will be discussed.

BI03: 1:50-2 p.m. Developing Effective Clicker Question Sequences for Helping Students Learn Quantum Mechanics

Contributed – Paul Justice, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Effective use of clicker questions in physics courses at all levels and in classes of all sizes can be an excellent formative assessment tool and can help students learn physics and develop their reasoning and metacognitive skills. Here we discuss our research on the development and evaluation of effective clicker question sequences for helping students learn quantum mechanics. We also discuss research evaluating an effective balance of peer discussions in small groups vs. general class discussions when students engage with different clicker question sequences.

BI04: 2-2:10 p.m. Evaluating JiTT and Peer Instruction Using Clickers in a QM Course

Contributed – Ryan T. Sayer, Bemidji State University, 1407 Beltrami Ave NW, Bemidji, MN 56601; rsayer@bemidjistate.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Just-in-Time Teaching (JiTT) is an instructional strategy involving feedback from students on pre-lecture activities in order to design in-class activities to build on the continuing feedback from students. We investigate the effectiveness of a JiTT approach, which included in-class concept tests using clickers in an upper-division quantum mechanics (QM) course. We analyze student performance on pre-lecture reading quizzes and in-class clicker questions answered individually and then again after group discussion, and compare those performances with open-ended retention quizzes administered after 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 discussions following individual clicker question responses also improved, as did the performance on retention quizzes administered at a later time. We discuss some possible reasons for the improved performance at various stages, e.g., from pre-lecture reading quizzes to post-lecture clicker questions, and from individual to group clicker questions and retention quizzes. We thank the National Science Foundation for support.

BI05: 2:10-2:20 p.m. Performance on In-class vs. Online Administration of Concept Inventories and Attitudinal Assessments

Contributed – Jayson M. Nissen, California State University Chico, 659 SW Jefferson Ave # 2, Corvallis, OR 97333; jayson.nissen@gmail.com

Xochith Herrera, Ben Van Dusen, California State University Chico

Manher Jariwala, Boston University

Eleanor Close, Texas State University

Measuring student growth and outcomes using concept inventories and affective surveys is a fundamental tool of physics education research. Historically this data has been collected using paper and pencil tests. However, the convenience of computer-based testing has led to many researchers and instructors administering research-based instruments using computers inside and outside of class. We used a stratified random sample of 1,645 students in three physics courses over two semesters to compare performance on concept inventories and affective surveys that were administered either in class as paper and pencil tests or online outside of class using the Learning About Student Supported Outcomes (LASSO) platform. We will discuss implications for these two methods of data collection for measuring changes in students' knowledge and attitudes.

BI06: 2:20-2:30 p.m. Evaluating Introductory Labs: The PLIC

Contributed – Natasha G. G. Holmes, Cornell University, 406-245 East Ave., Ithaca, NY 14853; ngholmes@cornell.edu

Katherine Quinn, Cornell University

Carl Wieman, Stanford University

A great deal of time and money is spent on science lab courses, but there is little evidence evaluating whether they are providing good educational value. Labs also suffer from a lack of consensus on goals and on accepted assessment instruments. In this talk, I will introduce the Physics Lab Inventory for Critical thinking, a new assessment under development and validation to fill this gap. It is aimed to assess students' proficiency with critical thinking as related to making sense of data, variability, and models and to assess the efficacy of lab courses at developing these skills. I will briefly outline the motivation and goals of the assessment, the development and validation efforts thus far, and early data and findings.

BI07: 2:30-2:40 p.m. Impact of Grading Practices on Students' Beliefs about Experimental Physics

Contributed – Bethany R. Wilcox, Colorado School of Mines, 2510 Taft Dr #213, Boulder, CO 80302, brwilcox@mines.edu

Heather J. Lewandowski, University of Colorado at Boulder

Student learning in undergraduate physics laboratories is a growing area of focus within the PER community. Lab courses have been called out as critical elements of the undergraduate curriculum, particularly with respect to improving students' attitudes and beliefs about experimental physics. Previous work within lab learning environments has focused on the effectiveness of curricular innovations or changes to pedagogy; however, one aspect of the learning environment that has not be investigated is the impact of grading practices on students' beliefs and practices. We explore the possible link between students' perceptions of what is valued and rewarded by course grades and their beliefs about the nature and importance of experimental physics as measured by the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS). We find that there is a significant correlation between students' perceptions of the value of certain activities and their personal epistemologies with respect to those activities.

BI08: 2:40-2:50 p.m. What Elements of GTA Development Do GTAs Find Most Useful?

Contributed – Emily Alicea-Munoz, Georgia Institute of Technology, 837 State Street, Atlanta, GA 30332; ealicea@gatech.edu

The School of Physics at Georgia Tech runs a preparation and development program for new Graduate Teaching Assistants (GTAs) that focuses on the integration of pedagogy, physics content, and professional development strategies. The program has been in effect for four years, has been well-received by the nearly one hundred graduate students who have participated in it, and has effected a positive impact on GTA teaching effectiveness. The program's curriculum is revised yearly based, in part, on feedback from the GTAs. Here we present an analysis of said feedback, focusing on what elements of GTA preparation our graduate students have found the most interesting and useful for their professional development.

BI09: 2:50-3 p.m. Identity and Skills Development of Physics Supplemental Instruction Leaders

Contributed – Sissi L. Li, California State University Fullerton, 800 N. State College Blvd., Fullerton, CA 92831-3547; sissili314@gmail.com

Supplemental Instruction (SI) is a program developed to target gateway courses with low passing rates. Students in these courses have the option to attend regular group problem-solving practice sessions outside of lecture. Each session is led by an SI leader, a student who has done well in the course and has applied for the position. While much of the research has focused on student success, this study examines the valuable skills SI leaders learn and the identities developed as a result of participation in the program. We have conducted interviews with SI leaders in physics to examine their general experience in the program and targeted facets of their development. We will present findings about the SI leaders' ideas about teaching and learning, their growth as content experts, and engagement as members of a community supporting academic success.

BI10: 3-3:10 p.m. Onsite Grading in Introductory Physics Laboratories

Contributed – Changgong Zhou, Lawrence Technological University, 21000 West Ten Mile Rd., Southfield, MI 48075-1058; czhou@ltu.edu

Study in cognitive psychology has shown that immediate feedback on learning can significantly improve knowledge and skill retention. However, introductory physics laboratory courses taught in conventional ways do not allow easy implementation of immediate feedback. In the ongoing process to renovate our lab curriculum, we overhaul our lab instruction model, which implements immediate feedback (both formative and summative) in the form of onsite grading. Students learn their grades before they leave the lab room. This presentation will discuss our onsite grading practice, the changes it brings to our lab curriculum design, and its impact on instructors' and students' behavior and mentality.

BI11: 3:10-3:20 p.m. Comparing Insights from Different Methods for Clustering Multiple-Choice Test Questions

Contributed – Mark Eichenlaub, University of Maryland, 8413 Potomac Ave., College Park, MD 20742-2421; mark.d.eichenlaub@gmail.com

Edward F. Redish, Deborah J. Hemingway; University of Maryland

Students taking a multiple-choice test generate more data than simply their final score, and a large class generates far more data than a single statistic can convey. Statistical techniques such as factor analysis and computations on network-based models can help us go from raw data to new insights on student learning, but only if we know how to interpret the results. As a case study in statistical meaning, we contrast results from applying factor analysis and network modularity maximization to data from two new survey instruments created as part of a project to study mathematical meaning-making in introductory physics for the life sciences. We ask what results would be expected given various models of student behavior, what results we actually see, and how quantitative results can go on to inform qualitative research.

Session BJ: PER: Examining Content Understanding and Reasoning

Location: Marriott - Covington Ballroom III
Sponsor: AAPT
Date: Monday, July 24
Time: 1:30–3:20 p.m.

Presider: Beverly Cannon

BJ01: 1:30-1:40 p.m. The Challenge of Making Sense of Mixed Metaphors in Quantum Mechanics

Contributed – David T. Brookes, California State University, Chico, 400 W. First St., Chico, CA 95929-0202; dbrookes@csuchico.edu

AJ Richards The College of New Jersey

Eugenia Etkina Rutgers, The State University of New Jersey

We will present an analysis of the discussions of a small group of preservice physics teachers learning about how a solar cell functions. As documented in the previous talk, part of the students' sense-making process involved using analogical reasoning. Beneath that we found another layer of sense-making that involved students trying to disentangle systems of conceptual metaphors embedded in the language of quantum mechanics. In our case study we see a student challenged by the mixed metaphors associated with an energy state of the system described as a location within the state, confused with the physical location of an object in space, and compounded with the location of the "energy level" itself. We have observed this difficulty before in earlier research (Brookes & Etkina, 2007)* and we suggest that such explorations of metaphorical overextensions are a necessary and key part of the sense-making process.

*Brookes, D. T., & Etkina, E. (2007). Using conceptual metaphor and functional grammar to explore how language used in physics affects student learning. Physical Review Special Topics Physics Education Research, 3(1), 010105. https://doi.org/10.1103/PhysRevSTPER.3.010105

BJ02: 1:40-1:50 p.m. Probing the Relationship Between Cognitive Reflection and Conceptual Learning*

Contributed – Cody Gette, North Dakota State University, 218 South Engineering, 1211 Albrecht Blvd., Fargo, ND 58108; cody.gette@ndsu.edu

Nathaniel Grosz, Mila Kryjevskaia, North Dakota State University

MacKenzie R. Stetzer, University of Maine

Andrew Boudreaux, Western Washington University

In many contexts in introductory physics, students who demonstrate correct conceptual knowledge and appropriate formal reasoning approaches on one physics task often abandon relevant knowledge in favor of perhaps more intuitively appealing lines of reasoning on isomorphic tasks. Dual-process theories of cognition suggest that such inconsistencies may stem from a fast, automatic, and intuitive process interfering with slow and analytical thinking. The Cognitive Reflection Test (CRT) has been developed in psychology to gauge the tendency of a reasoner to engage analytical thinking to evaluate (and possibly override) initial intuitive ideas. In our ongoing, multi-institutional project, we have been exploring the use of the CRT and concept inventories (e.g. FMCE) to probe the relationship between cognitive reflection and learning gains in physics.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431541, 1431940, 1432052, 1432765.

BJ03: 1:50-2 p.m. Probing the Relationship Between Cognitive Reflection and Student Reasoning*

Contributed – Mila Kryjevskaia, North Dakota State University, Department of Physics, Fargo, ND 58108-6050; mila.kryjevskaia@ndsu.edu

Nathaniel Grosz, Cody Gette, North Dakota State University

As part of a multi-year, multi-institutional effort, we have been investigating the development of student reasoning skills in physics courses. In particular, we have been focusing on the identification of factors and instructional circumstances that appear to enhance or suppress the application of correct reasoning approaches. Previously, we employed the Cognitive Reflection Test (CRT) to measure students' abilities to engage analytical thinking to evaluate (and possibly override) initial intuitive ideas. We have identified a strong correlation between CRT scores and learning gains, as measured by the FMCE. In this presentation, further evidence for the impact of cognitive reflection skills on students' learning will be discussed. A correlation between CRT scores and student performance in the specific context of frictional forces will be examined. Implications for instruction will be discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. 1431857, 1431541, 1431940, 1432052, 1432765.

BJ04: 2-2:10 p.m. Dual-Process Theory: A Lens for Interpreting Student Reasoning*

Contributed – Andrew Boudreaux, Western Washington University, 516 High St., Bellingham, WA 98225-9164; andrew.boudreaux@wwu.edu

Cody Gette, Nathanial Grosz, North Dakota State University

Beth Lindsey, Penn State Greater Allegheny

Mackenzie R. Stetzer, University of Maine

Dual-process theories of cognition posit two largely distinct modes of thinking: an automatic, "intuitive" process, and a deliberate, analytic process. Instructors might naturally expect students to engage the latter when working on problems in a physics course. In an ongoing, multi-institution collaboration, however, we have found evidence that the intuitive process can "interfere" with step-by-step reasoning in interesting ways. In this talk, we present students' written explanations and in-the-moment sense-making talk from classroom video to identify specific reasoning difficulties. We then interpret these difficulties through the lens of dual-process theories.

* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

BJ05: 2:10-2:20 p.m. Modifying Chaining Tasks to Explore Dual-Process Theories of Reasoning*

Contributed – MacKenzie R. Stetzer, University of Maine, Department of Physics, 5709 Bennett Hall, Room 120, Orono, ME 04469-5709; mackenzie.stetzer@maine.edu

J. Caleb Speirs, University of Maine

Mila Kryjevskaia, North Dakota State University

As part of a larger effort to investigate and assess the development of student reasoning skills in physics, we have been designing tasks that examine student ability to generate qualitative, inferential reasoning chains. In an online "chaining" task, students are provided with correct reasoning elements (i.e., true statements about the physical situation as well as correct concepts and mathematical relationships) and are asked to assemble them into an argument in order to answer a physics problem. We have recently begun modifying these chaining tasks in order to better explore the extent to which some reasoning phenomena in physics may be accounted for by dual-process theories of reasoning. In this talk, an overview of these modified chaining tasks will be provided and preliminary results will be discussed.

* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

BJ06: 2:20-2:30 p.m. Using Chaining Task Interviews to Explore Dual-Process Theories of Reasoning*

Contributed – Beth A. Lindsey, Penn State Greater Allegheny, 4000 University Dr., McKeesport, PA 15132; bal23@psu.edu

Andrew Boudreaux, Western Washington University

MacKenzie R. Stetzer, J. Caleb Speirs, University of Maine

As part of a multi-institution collaboration, we are examining students' multi-step, qualitative reasoning in physics. We have previously presented results from online tasks and interviews in which students were provided with reasoning elements (i.e., statements about fundamental concepts or the specific physical situation) and were asked to assemble them into reasoning chains in support of their answers. Results from online tasks could be accounted for using dual-process theories of reasoning, which suggest that two distinct processes are involved in reasoning: a fast, automatic, "intuitive" process (system 1) and a slower, analytical, and rule-based process (system 2). In this talk, we will present data from one-on-one interviews with students and interpret results using dual-process theories. Implications for instruction will be discussed.

* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

BJ07: 2:30-2:40 p.m. Student Mathematization and Conceptual Understanding of Differential Area Elements

Contributed – Benjamin P. Schermerhorn, University of Maine, 5709 Bennett Hall, Orono, ME 04469; benjamin.schermerhorn@maine.edu

John R. Thompson. University of Maine

As part of an effort to examine how students determine and understand differential vector elements in the various non-Cartesian coordinate systems used in electricity and magnetism (E&M), students in junior-level E&M were interviewed. As the students progressed through typical E&M vector calculus problems, they were asked to elaborate on their choices of differential vector elements. The more successful students articulated how differential lengths and areas are constructed given the varying physical situations and the relevant symmetry. However, in several cases, students correctly explained the meaning of these differential elements within their given physical contexts, but were subsequently unable to construct appropriate symbolic representations. This latter result differs from prior work with differential length elements. Potential explanations for the difference will be discussed.

BJ08: 2:40-2:50 p.m. Addressing Student Ideas About Coordinate Systems in the Upper Division

Contributed – Brian D. Farlow, North Dakota State University, Physics Department, NDSU Dept. 2755 PO Box 6050, Fargo, ND 58108; brian.farlow@ndsu.edu

Warren Christensen, North Dakota State University

Marlene Vega, Michael Loverude, Cal State Fullerton

As part of a broader study on student thinking about mathematics in the undergraduate physics curriculum, we have developed instructional materials intended to promote productive student thinking about non-Cartesian unit and position vectors. Previous work has identified ideas that undergraduate physics students bring to bear while attempting to solve non-Cartesian coordinate system problems: resources for unit vectors, resources connecting polar vector elements to Cartesian vector elements, and the orthogonality of basis vectors in various coordinate systems. In previous studies, these resources are not always used productively, so these instructional materials seek to explicitly guide students to do so. We report on the development and pilot testing of this intervention among junior/senior-level undergraduate students.

BJ09: 2:50-3 p.m. Assessing Thinking Skills

Contributed – Beth Thacker, Texas Tech University, Physics Dept., MS 41051, Lubbock, TX 79409-1051; beth.thacker@ttu.edu

Zhuang Zhuang, Texas Tech University

We discuss the analysis of thinking skills as evidenced in students' written solutions to free-response homework and exam problems in a laboratory-based, inquiry-based class compared to more traditional class settings. We used a rubric based on Bloom's taxonomy. We present our results and the results of interviews of students on one of the problems.

BJ10: 3-3:10 p.m. Examining Student Ability to Reason in Different Directions*

*Contributed – William S. Johnson,** University of Maine Department of Physics, 5709 Bennett Hall, Room 120, Orono, ME 04469-5709; william.s.johnson@maine.edu*

J. Caleb Speirs, William N. Ferm Jr., MacKenzie R. Stetzer, University of Maine

As part of a multi-institutional effort to investigate and assess the development of student reasoning skills in the context of scaffolded physics instruction, we have designed and administered tasks that probe student ability to reason in different directions in introductory calculus-based courses. In these reasoning reversal tasks, two different versions of a physics problem are randomly administered to the students. In one version, students are asked to predict how a modification to an experimental setup will change the outcome of the experiment; in the other version, students are asked to infer the modification to the experimental

Monday afternoon

setup that led to a specified change in the experimental outcome. In this talk, modifications to these tasks will be discussed and new results will be presented.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805. **Sponsored by MacKenzie Stetzer.

BJ11: 3:10-3:20 p.m. Using Johnson-Laird's Mental Models Framework to Examine Student Reasoning*

Contributed – J. Caleb Speirs, University of Maine, 5709 Bennett Hall, Orono, ME 04469; caleb.speirs@gmail.com

MacKenzie R. Stetzer, University of Maine

Beth A. Lindsey, Penn State Greater Allegheny

Mila Kryjevskaia, North Dakota State University

As part of a multi-year, multi-institutional effort, we have been investigating and assessing the development of student reasoning skills in introductory calculus-based physics courses. Recently, we have begun to examine student reasoning in physics through the lens of Johnson-Laird's mental models framework. In particular, we have piloted new tasks designed to measure student ability to consider multiple mental models when answering a physics problem. It is hoped that the development of such tasks will enable us to explore possible relationships between that ability and student performance on physics problems in which salient distracting features appear to prevent students from drawing upon relevant conceptual understanding. In this talk, illustrative mental models tasks will be highlighted and preliminary results will be discussed.

* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

Session BK: Topics in Diversity I

Location: CC - Breakout 9
Sponsor: AAPT
Date: Monday, July 24
Time: 2–3:30 p.m.

Presider: Brad Ambrose

BK01: 2-2:30 p.m. Survival Skills for New High School Teachers

Invited – Jeffrey A. Rodriguez, Anderson High School, 8593 Coran Drive, Cincinnati, OH 45255; jeffrodriguez@foresthills.edu

Are you ready to start an exciting teaching career? Inquisitive students, grading papers, communicating with parents, faculty meeting after school, applying technology and preparing lesson plans, video of you teaching your class for license requirements, setting up a lab demonstration, and a fire drill today. The life of a teacher has great intrinsic benefits, is never dull or without daily challenges. These challenges and other issues can be overwhelming without the proper skills, strategies, and guidance. Using teaching experience in urban and suburban districts, interviews of new teachers, and a review of current literature, I will present a set of survival skills for new teachers so you can enjoy your career choice.

BK02: 2:30-2:40 p.m. Physics Identity in High School: Impact of Discussing Women's Underrepresentation

Contributed – Robynne M. Lock, Texas A&M University - Commerce, Dept. of Physics & Astronomy, Commerce, TX 75429; robynne.lock@tamuc.edu

Matthew Witt, Texas A&M University - Commerce

Zahra Hazari, Florida International University

In previous work, we found that discussing the underrepresentation of women in science correlates with physics identity and with physics career choice. To determine whether there is a causal effect, we conducted a quasi-experiment with students in high school physics classes. Two teachers, each of whom taught multiple physics classes, implemented lessons about women in physics in their classes. Students in half of each teacher's classes read about famous female physicists, including the challenges they have overcome, and then held a classroom discussion about these physicists and the state of women in physics today. The other half of the classes read about the work of modern day female physicists with no emphasis placed on their gender, but these students did not have a class discussion. All students wrote pre- and post-essays and completed pre- and post-surveys. In this work, we examine the effect of these lessons on students' physics identities.

BK03: 2:40-2:50 p.m. Ethnographic Study of Transfer Students in Upper Division Physics Courses

Contributed – Mary K. Chessey, University of California Davis, One Shields Avenue, Davis, CA 95616-5270; mkchessey@ucdavis.edu

David J. Webb, University of California Davis

The results of a year-long study focused on the experiences of a cohort of 40 transfer students taking upper division undergraduate physics courses are presented. By observing interactions and taking ethnographic field notes during classes, office hours, informal help sessions, and self-organized student group work as well as by interviewing transfer students and their instructors, patterns of behavior and social norms that influence success in the field can be described and analyzed. Specifically, aspects of student experiences related to instructor and peer feedback of various forms and the ways transfer students use this feedback are explored. This work contributes to the understanding of how education in physics tends to push women and students of color out of the field at disproportionate rates.

BK04: 2:50 -3 p.m. Doctor Habbibi: Muslim Women Identities in the Pre-Medicine College Track

Contributed – Sidra F. Ali, Rutgers University- Newark, 20 Williams Avenue, Jersey City, NJ 07304; sidrafali17@gmail.com

Diane Jammula, Rutgers University- Newark

After 9/11, 1.6 billion Muslims were held responsible for an attack committed by 16 men from Saudi Arabia. Muslims in the U.S. were subjected to bigotry, again heightened in the Trump presidency. College campuses seek to create safe spaces as Muslim students strive for the "American Dream." Muslim women are stereotypically thought of as oppressed, and pursuing medicine while living in Islamophobia may seem contradictory. A case study was conducted at a minority-serving institution to answer these research questions: 1) How do female Muslim college students negotiate their familial, social, and academic identities while pursuing the pre-medicine track? 2) What supports and obstacles do they encounter? 3) How do they deal with stereotypes and images projected by the media and society? Participants were female Muslim students on the pre-med track representing a range of backgrounds and perspectives. Interviews were conducted and analyzed using open coding. Findings discuss emergent themes.

Session BL: K-12 PER

Location: CC - Breakout 10
Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 24
Time: 1:30–3:30 p.m.

Presider: Dan Crowe

BL01: 1:30-2 p.m. Conceptual Problem Solving in High School Physics*

Invited – Jennifer Docktor, University of Wisconsin - La Crosse, 2030 Cowley Hall, 1725 State St., La Crosse, WI 54601; jdocktor@uwlax.edu

Jose Mestre, University of Illinois at Urbana-Champaign

Problem solving is an important part of physics, yet can prove challenging for instructors to teach and students to learn. In spite of our best efforts, beginning students often focus on equations and mathematical procedures rather than considering the conceptual underpinnings of the solution process. In this talk, I will describe an instructional framework called Conceptual Problem Solving which guides students to identify principles, justify their use, and plan their solution in writing before solving a problem. I will also highlight the findings of a study where the approach was implemented in three different high school settings.

*Work supported in part by the Institute of Education Sciences of the U.S. Department of Education under Grant No. DE R305B070085

BL02: 2-2:30 p.m. Connecting Three Pivotal Concepts in K-12 Science State Standards and Maps of Conceptual Growth to Research in Physics Education

Invited – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Christian Dieter Schunn, University of Pittsburgh

We discuss three conceptual areas in physics that are particularly important in K-12 science. These conceptual areas are force and motion, conservation of energy, and geometrical optics, which were prominent in the U.S. national and four U.S. state standards that we examined. The four U.S. state standards that were analyzed to explore the extent to which the K-12 science standards differ in different states were selected to include states in different geographic regions and of different sizes. These three conceptual areas that were common to all the four state standards are conceptual building blocks for other science concepts covered in the K-12 curriculum. As key conceptual building blocks, they are also important in the NGSS. We discuss the nature of difficulties in these areas along with some PER-based approaches that have been found to be effective to help students learn these concepts. Some general PER-based approaches that can improve student learning in K-12 classrooms will also be discussed. We thank the National Science Foundation for support.

BL03: 2:30-2:40 p.m. Sparking Curiosity: Physical Science for Elementary Teachers

Contributed – Wendy K. Adams, University of Northern Colorado & Colorado School of Mines, 501 20th Street, Greeley, CO 80639; wendy.adams@unco.edu

Heather Taffe, Ansel Foxley, Kui Chen, University of Northern Colorado

Adrianne N. Larson, University of Northern Colorado/ Chicago Public Schools

PhysTEC support has allowed three new faculty members to adopt our research-based curriculum in the Physical Science Concepts for Elementary Teachers course at the University of Northern Colorado. This curriculum frames the material in contexts that students are personally interested in and uses several different interactive engagement techniques including Peer Instruction, Just in Time Teaching, and devotes nearly half the instructional time to hands on activities appropriate for the elementary classroom. In this poster we will share pre/post conceptual data as well as CLASS results for the course before and after this new curriculum. The new instructors are showing student normalized learning gains between 64% and 76% and their students' personal interest in physics, as measured by the CLASS, increases between 6% and 22% as compared to decreasing by 13% when taught traditionally.

BL04: 2:40-2:50 p.m. When We Teach Rays of Light?

Contributed – Jung-Bog Kim, Korea National University of Education, Dept of Physics Education, Cheongju, CB 28173 S. Korea; jbkim@knue.ac.kr

Gyeong Jin Lee

In order to compare elementary school students' understandings about "light ray" according to the grades, we developed the teaching materials for elementary school students. The subjects of the study were total 162 students in 3rd, 4th, 5th, and 6th grades. The results of this study show that understanding about light rays according to the shapes of light sources is very high in both 5th and 6th grades.

BL05: 2:50-3 p.m. Curricular Resources for NGSS Implementation: PER in an NGSS-aligned Classroom

Contributed – Julian S. Martins, University of Colorado - Boulder, 249 UCB, Boulder, CO 80309; julian.martins@colorado.edu

William E. Lindsay, Shelly N. Belleau, Valeri K. Otero, University of Colorado - Boulder

The Next Generation Science Standards (NGSS) seek to combine disciplinary and cross-disciplinary science concepts with scientific practices. However, in contemporary or historical the literature, few examples actually illustrate what such a course looks like in practice. The NGSS-aligned Physics and Everyday Thinking-High School (PET-HS) curriculum is designed to foster an environment where students induce physics principles from their observations utilizing scientific practices, such as making inferences from evidence and engaging in argumentation. Through an in-depth, mixed-methods research study in eight high school classes using the PET-HS curriculum, we illustrate ways in which the NGSS are embraced and enacted by students and teachers. Student outcomes, class observations, student/teacher interviews, and video recordings are used to distill a set of principles that guide the socio-cognitive and socio-emotional considerations that are critical to successful implementation of the NGSS. These principles will be illustrated and discussed and implications for instruction will be made.

BL06: 3-3:10 p.m. Learning Physics by Practicing It: A Peak into a Classroom

Contributed – Danielle Bugge, Rutgers University, 8 Perrine Path, West Windsor, NJ 08550; danielle.bugge@rutgers.edu

Eugenia Etkina,Rutgers University

Recommendations of the Next Generation Science Standards and Advanced Placement Physics 1 and 2 guidelines have necessitated change in high school physics classrooms. High school students are expected to achieve proficiency with the science practices but what does this proficiency look like in the classroom? The goal of this talk is to share how a group of high school physics students achieved proficiency on the standards set by NGSS and AP when learning physics through the Investigative Science Learning Environment (ISLE) method. When learning physics through ISLE, students regularly design their own experiments. They work collaboratively in teams and then share their findings in either individual or group reports. The students consistently revise their work and self-assess and reflect on what they have learned. We will present and analyze examples of student work to show how all of the above activities connect to NGSS.

BL07: 3:10-3:20 p.m. Gender and Context Choice Influence on Student Performance and Attitude

Contributed – Samuel Wheeler, North Carolina State University, 1907 Carnation Dr., Durham, NC 27703; srwheele@ncsu.edu

Margaret Blanchard, North Carolina State University

This study investigates the role that student choice and gender stereotypes have on student interests, beliefs, conceptual understanding, and motivation toward learning physics in a high school unit on Newton's Laws. Seventy four student participants in high school physics classes, from five U.S. states, took part in this study. WebAssign homework problems were designed to investigate whether the context of a physics question, based on gender preferences, will influence students' choices. Three question contexts were used: traditional physics, biological health, and sports. Students were given a pre post Force Concept Inventory to evaluate conceptual knowledge, and a pre/post CLASS survey to measure changes in attitudes. Female participants showed greater gains in conceptual understanding compared with males and showed improvements in sense making and applying conceptual understanding. The findings suggest that given a choice of context, students are more engaged and interested in the physics and show growth in understanding the concepts.

BL08: 3:20-3:30 p.m. Socio-Cultural and Socio-Cognitive Curricular Expectations: Tensions in PET-HS Implementation

Contributed – William E. Lindsay, University of Colorado Boulder, 249 UCB, Boulder, CO 80309-0249; lindsawe@colorado.edu

Julian S. Martins, Shelly N. Belleau, Valerie K. Otero, University of Colorado Boulder

Tensions often arise in the implementation of novel curricula or teaching philosophies. This may result from incongruences between curricula expectations and the realities of diverse schooling environments. The PET-HS curriculum supports "three-dimensional learning" promoted in the Next Generation Science Standards (NGSS) and encourages a shift from the pedagogies and practices used by teachers before implementing PET-HS. Using a Cultural Historical Activity Theory framework, our physics education research team documented tensions that occurred when implementing the Physics and Everyday Thinking-High School (PET-HS) curriculum in seven high schools. Preliminary findings indicate that misalignment of explicit and implicit socio-cultural and socio-cognitive expectations of the PET-HS curriculum for students and teachers often led to tensions surrounding group work, evidence usage, and facilitation of consensus discussions. From our findings, we have established mechanisms for preparing teachers for managing such tensions when attempting to engage in three-dimensional learning.

Session CA: Panel – Electricity, Energy, and Particles: Squishy Circuits, Scribble Bots, and the Particle Zoo

Location: Marriott - Covington Ballroom I
Sponsor: Committee on Physics in Pre-High School Education
Co-Sponsor: Committee on Women in Physics
Date: Monday, July 24
Time: 4–6 p.m.

Presider: Elizabeth Holsenbeck

The format will be stations for the teachers to rotate to each topic/content/learning cycle during the time allowed. Each station will have two teachers to work with the participants at their table.

CA01: 4-6 p.m. PTRA: What is Squishy, Moves and Is Really, Really Small?

Panel – Elizabeth Holsenbeck, Alabama State University, 5062 Cty Rd 13, Hardaway, AL 36039; eholsenbeck@alasu.edu

Experience the world from a different view point. See how K-8 science has evolved and how PTRA can help you. Participants will engage in three inquiry activities.

Panelists:

Janie Head, Simonton, TX

Elaine Gwinn, Middletown, IN

Jan Landis Mader, Great Falls, MT

Karen Jo Matsler, Arlington, TX

Session CB: Panel – 30 Demos in 60 Minutes

Location: Marriott - Covington Ballroom III
Sponsor: Committee on Teacher Preparation
Co-Sponsor: Committee on Physics in Pre-High School Education
Date: Monday, July 24
Time: 4–5 p.m.

Presider: Wendy Adams

Our panel of physics teachers will present at least 30 dynamic demonstrations that will engage students in the wonder of science. Presenters will share tips on the setup, materials, procedure, and underlying science concepts so the audience can integrate these demos into their own classrooms.

Panelists:

Gary White, George Washington University

John Stewart, West Virginia University

Dave Maiullo, Rutgers University

James Lincoln, PhysicsVideos.com

Toni Sauncy, Texas Lutheran University

Session CC: Introductory Labs/Apparatus

Location: CC - Breakout 4
Sponsor: AAPT
Date: Monday, July 24
Time: 4–5:30 p.m.

Presider: Herbert Jaeger

CC01: 4-4:10 p.m. A Comparative Study of Discovery Learning Scientific Community Laboratories and Traditional Laboratories in Physics

Contributed – Muhammad Riaz, Florida Institute of Technology, 150 W University Blvd., Melbourne , FL 32901; riaznorth@gmail.com

Thomas J. Marcinkowski, Florida Institute of Technology

A comparative study to determine the relationship of two different instructional approaches – Discovery Learning Scientific Community Laboratories (DL-SCL; experimental) and non-DLSCL laboratories (control) – to students' conceptual understanding, and achievement in a physics-1 lab was conducted during fall semester 2016, at a private scientific and technical university, at Melbourne, FL. Moreover, within the context of this study, students' conceptual understanding is measured as the change in students' pre- and post-test scores on the Mechanics Baseline Test (MBT) for the members of each group. The students' lab score in each lab is used to define student achievement and success in the course. Objective: The purpose of this study is to transform traditional content of physics-1 lab into discovery-based learning and taught through DL-SCL approach. Traditional physics laboratory content has great potential, particularly when that content is taught through the DL-SCL for guiding students to adopt scientific conception.

CC02: 4:10-4:20 p.m. Development of an Online Lab Course for Introductory Physics

Contributed – Nicole Cronin, SUNY Stony Brook, 100 Nicolls Road, Stony Brook, NY 11794; nicole.cronin@stonybrook.edu

Thomas Hemmick, Anthony Bassante, Aneta Iordanova, Christopher Zangler-Scaduto, SUNY Stony Brook

At Stony Brook University, there has been an increased push in the development of online courses. For the past three years, the introductory physics lecture course has been successfully implemented online, but students are still required to physically be on campus for labs. With the help of the iOLab device developed at the University of Illinois, there is an ongoing effort to change this. A total of 20 labs were produced for both semesters of the two-course lab sequence, with a total of eight being unique to Stony Brook. A pilot class, with 30-40 students, was held for both lab courses. Lab manuals and introductory videos were delivered to the students through the associated iOLab software. The success of this class, in terms of student performance and motivation, was assessed through surveys, focus groups and lab quizzes. Full implementation of the course, with 250 students, is currently ongoing.

CC03: 4:20-4:30 p.m. Effects of a Design-style Lab in Introductory Algebra-based Mechanics

Contributed – William R. Evans, University of Illinois at Urbana-Champaign, 1208 Devonshire Dr., Champaign, IL 61821; wevans2@illinois.edu

Mats A. Selen, University of Illinois at Urbana-Champaign

At the University of Illinois, we have piloted a new design-style laboratory that focuses on sense-making and the acquisition of scientific skills. These reforms were previously piloted in our calculus-based introductory mechanics course for physics and engineering majors. This is the first year we piloted the same reforms in our algebra-based introductory mechanics course, which primarily serves life science students. We collected data on both students' attitudes and conceptual learning using traditional instruments. We compare these data from students in the reformed laboratory sections with data from students in the more traditional step-by-step guided labs. We will also report a comparative analysis of these students with students in calculus-based introductory mechanics, both in the traditional and reformed labs, and with published results from other course reforms serving life science students in introductory physics.

CC04: 4:30-4:40 p.m. Supplemental Instructional Laboratory Activities in Introductory Physics

Contributed – Sara J. Callori, California State University San Bernardino, 5500 University Parkway, San Bernardino, CA 92407-2318; United States sara.callori@csusb.edu

Historically, our department's introductory labs could easily be described as "cookbook", with an outsized emphasis on quantitative error propagation that makes it difficult to reinforce the concept knowledge from the lecture portion of the course. In an effort to combat this, we have been piloting different types of supplemental lab activities, done both as pre-lab exercises and as open-ended hands-on tasks. Pre-lab activities ask students to use PhET or other simulations in order to investigate the concepts they will see in the coming session. In lab, students are given "Challenge Questions" in additional to the regular lab activity. These questions ask students to use the outcomes and skills learned in the first part of the session in order to answer an open-ended question. Here I will discuss motivations for incorporating these activities into the curriculum, show examples of these tasks, and reflect on their implementation.

CC05: 4:40-4:50 p.m. Identifying Three Common Difficulties in Causal Reasoning Using Think-Aloud Protocols

Contributed – Lindsay Owens, University of Cincinnati, 3843 Mantell Ave., Cincinnati, OH 45236; owensly@mail.uc.edu

Kathy Koenig, University of Cincinnati

Lei Bao, The Ohio State University

Students use causal reasoning in their everyday lives to generate hypotheses as to why an event occurred, or to create predictions about future events based on personal experience and/or data. Yet, students in introductory physics labs quickly demonstrated difficulties in causal reasoning when interacting with story-based scenarios and data. Qualitative think-aloud interviews were conducted with a variety of both algebra-based and calculus-based students; students verbally reasoned through causal scenarios which featured causal mechanisms, covariation data, or both. The most commonly identified difficulties were (1) interchanging causation with correlation, (2) interchanging forward and reverse causality, and (3) difficulty in identifying necessary causes. These difficulties will be discussed within the talk.

CC06: 4:50-5 p.m. Constructing 3-D Models of Electric Fields and Potentials

Contributed – Nathan David Powers, Brigham Young University, 3046 W 770 N, Provo, UT 84601; ndp5@byu.edu

Anna Bell, Will Oldroyd, Brigham Young University

For years we have used conductive boards as a way of mapping electric fields from equipotential lines. While this exercise can be useful for illustrating the effect of different configurations on the electric field map, it has been less effective at helping students develop a concrete understanding of the somewhat abstract concepts of voltage, electric fields, and electric potentials. I will discuss a conceptual model building activity in which students take measurements and make predictions about a 3-D gravitational representation of the 2-D board. The students then compare and contrast the gravitational analogue with the abstract electrical concepts. We expect that the cognitive effort required to identify correlations between what at first appears to be two unrelated experiments will improve conceptual understanding.

CC07: 5-5:10 p.m. Redesign of Introductory Physics Labs Using Arduinos

Contributed –Troy C. Messina, Berea College, 101 Chestnut Street, CPO 2191, Berea, KY 40404; messinat@berea.edu

The Arduino microprocessor platform has made possible inexpensive prototyping and experimentation. The simplicity of programming the Arduino makes it a great tool for introducing students to computer programming, experimental design, sensor calibration, and data acquisition. We will explain the Arduino platform and show how it can be used in a variety of traditional introductory physics labs as well as some less typical introductory physics experiments.

CC08: 5:10-5:20 p.m. Incorporating Arduino Applications into Coding and Magnetism Curriculum

Contributed – Deborah Roudebush, Retired, 4410 Mariner Lane Fairfax, VA 22033 droudebush@cox.net

Coding is an important skill for our 21st century job market. To that end, incorporating coding into the curriculum using arduino technology will help prepare high school physics students for university studies and the future job markets. Examples of activities that incorporate arduino use will be discussed.

CC09: 5:20-5:30 p.m. Experimenting with Investigative Labs with the IOLab

Contributed – Louis Leblond, Penn State University, 104 Davey Lab, University Park, PA 16802L; lul29@psu.edu

I will describe our recent transition at Penn State to newly designed introductory labs that are inspired by the Investigative Science Learning Environment (ISLE). The labs use almost exclusively a single versatile tool, the IOLab. We did a gradual pilot phase going from small classes (~40) to our large enrollment course (~1000 students). I will report on conceptual learning gains and on attitude toward physics and toward physics labs. For every semester of the pilot, we have tweaked and improved the labs. We find that the new labs are just as good for learning the physics concepts as the old procedural lab but they now promote and assess critical thinking learning objectives. I will discuss difficulties we have faced and possible improvements.

Session CD: Lab Recommendations Focus Area 5: Technical and Practical Skills

Location: CC - Breakout 5
Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 24
Time: 4–6 p.m.

Presider: Joseph Kozminski

CD01: 4-4:30 p.m. Framework for Developing and Assessing Physics Student Technical Competencies

Invited – Randall Tagg, University of Colorado Denver, Physics Dept - Campus Box 157 P.O. Box 173364, Denver, CO 80217-3364; randall.tagg@ucdenver.edu

The AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum identify several aspects of technical and practical knowledge that are important to students at both introductory and advanced levels. From simple instruments like Vernier calipers and digital multimeters to complex instruments like lockin amplifiers and specialized detectors, students gain professionally important knowledge through operation and modeling of scientific equipment. Equally important is student capacity and self-confidence in the design and fabrication of apparatus of increasing levels of sophistication, including the use of various types of computers for data acquisition and experiment control. A systematic framework is possible for identifying, assessing, and potentially certifying technical competencies across the incredibly broad arena of instruments and technologies accessible to physics students. This opens up many opportunities for collaboration and student contribution in bringing this framework to fruition.

CD02: 4:30-5 p.m. Progress Towards New Experimental Techniques Subject for Second-Year Physics Majors

Invited – Sean P. Robinson, MIT, 77 Mass Ave., Room 4-362, Cambridge, MA 02139-4307; spatrick@mit.edu

I will report on progress towards developing a new elective subject aimed at second-year physics majors at MIT on the broad topic of experimental techniques. The course will employ hands-on laboratory exercises tightly coordinated with classroom instruction. Subject matter will focus on foundational techniques and tools common to modern experimental physics: materials, vacuum, cryogenics, magnets, high voltage, beams and radiation, analog and digital electronics, data acquisition and controls, signal processing, and visualization. A secondary goal is to promote a positive image of the "hands-on physicist" to students, empowering them to take on this identity themselves, and dispelling the illusion that success in physics requires becoming a "black board physicist". The new subject will complement our existing "Junior Lab" modern physics advanced lab subject, whose primary emphasis is the professional and personal development of the student as a scientist through the medium of experimental physics.

CD03: 5-5:30 p.m. Developing Technical Laboratory Skills in an Upper Division Optics Course

Invited – Paul C Arpin, CSU Chico Department of Physics, 400 West First Street, Chico, CA 95929-0202; parpin@csuchico.edu

The AAPT Lab Guidelines recommend that a learning goal of physics lab courses should be that students develop the ability to make measurements with a range of standard lab equipment and understand the limitations of their measuring devices. In this talk, I will discuss the modification of labs in an upper division optics course aimed at giving students more opportunities to develop these skills and demonstrate them in a way that an instructor can assess. Examples include changes such as incorporating CCDs into existing imaging labs to enable students to perform a quantitative analysis of the limitations of both the optical system and the detector and incorporating additional design focused labs where students must choose appropriate optical components for their experiment and align the optical system.

CD04: 5:30-6 p.m. Practical Skills: Using Pop-Up Classes to Augment Student Know-How

Invited – Linda S. Barton, Rochester Institute of Technology, 86 Lomb Memorial Dr., Rochester, NY 14623; lsbsps@rit.edu

An informal survey of physics majors conducted over several years at RIT reveals some stunning deficiencies in students' practical and technical skills. Students need many of these hands-on skills as they move into experimental research projects. Pop-up courses are non-credit bearing short courses outside the regular curriculum. Pop-ups provide a fun and easy way to address practical skills development. We have developed and delivered several pop-up courses and are looking forward to bringing forward more in the near future. Strengths, as well as difficulties, with the implementation of pop-ups will be discussed.

Session CE: Developing and Using Next-Generation Simulations

Location: CC - Breakout 6
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Apparatus
Date: Monday, July 24
Time: 4–5:50 p.m.

Presider: Mario Belloni

CE01: 4-4:30 p.m. Next-Generation PhET Simulations: New Opportunities for Teaching, Learning, and Assessment

Invited – Katherine K. Perkins, University of Colorado Boulder, UCB 390, Boulder, CO 80309; katherine.perkins@colorado.edu

Emily B. Moore, University of Colorado Boulder

the PhET Team

From the diversification of educational devices to the adoption of the NGSS to the emergence of personalized and adaptive learning environments, physics education, and education technology are in a period of rapid change and unprecedented opportunity. In this session, we will highlight our efforts to create next-generation simulations – a suite of simulations that are more flexible, more interoperable, more engaging, and importantly, more accessible to students with disabilities. We will introduce PhET-iO simulations which bring new capabilities to flexibly customize and fully integrate the simulations into an instructional wrapper, and then capture data on student interaction. We will also describe our approach to bringing science inquiry to students with disabilities. Throughout, we will ground the talk in examples of what next-generation sim-based learning and assessment can look like in the classroom and online.

CE02: 4:30-5 p.m. Next Generation Open Source Physics Simulations

Invited – Wolfgang Christian, Davidson College, 167 Catalina Dr., Mooresville, NC 28117-8564; wochristian@davidson.edu

HTML-5 with JavaScript has become the platform of choice for computer-based interactive engagement teaching and curriculum development. This talk describes innovative uses of the Easy Java/JavaScript Simulations (EJS) modeling and authoring tool to enable students, teachers and curriculum developers to bridge the gap between desktop computers and mobile devices. Examples will include HTML-5 based simulations of physical systems that respond to the orientation of a mobile device, captive portals that mirror an instructor's simulation on student mobile devices while simultaneously collecting student responses, and new curricula packaged in ComPADRE books, as EPubs, and as standalone mobile apps. Our tools and many ready-to-run examples are freely available from the Open Source Physics Collection hosted on the AAPT-ComPADRE digital library.

CE03: 5-5:30 p.m. Interactive Video Vignettes for Introductory Physics Courses*

Invited – Robert B. Teese, Rochester Institute of Technology, 56 Lomb Memorial Drive, Rochester, NY 14623; rbtsps@rit.edu

Priscilla W. Laws, Dickinson College

Kathleen Koenig, University of Cincinnati

Interactive Video Vignettes (IVVs) are web applications that combine video with required interactive elements such as video analysis, graphing, and questions. Vignette Studio, the free software developed in this project for authoring IVVs, can be downloaded from ComPADRE (www.compadre.org/IVV). Related projects for advanced physics labs and introductory biology developed new interactive elements. For example, with question-based branching, each possible answer to a multiple-choice question can link to a different subsequent page for individualized remediation. Nine sample IVVs on ComPADRE illustrate several styles and teaching techniques. They were based on research-validated curricular frameworks and student misconception research. Through a partnership with Cengage, six additional IVVs have been completed and others are in production. These IVVs will be available on WebAssign later this year. Pre/post data on over 3000 students of 17 faculty shows that these materials are effective at teaching hard-to-learn physics concepts.

*Supported in part by a publishing partnership with Cengage and NSF grants 1123118, 1122828, 1245147 and 1432286.

CE04: 5:30-5:40 p.m. A Game-Centered, Interactive Approach for Using Programming Exercises in Introductory Physics

Contributed – Chris Orban, The Ohio State University, 1465 Mt Vernon Ave., Marion, OH 43302-5628; orban@physics.osu.edu

Chris D. Porter, Joseph R. Smith,Nash Brecht, The Ohio State University

Richelle Teeling-Smith, Marion Technical College / University of Mt. Union

Incorporating computer programming exercises in introductory physics is a delicate task that involves a number of choices that may have a strong affect on student learning, especially for absolute beginner programmers. We present a set of hour-long activities for classical mechanics that resemble well-known games such as "asteroids," "lunar lander," and "angry birds" as well as more sophisticated interactive visualizations. These activities use a browser-based programming framework called p5.js that provides a game-like environment to give students a feel for the physics. This framework can also be used to highlight the physics part of the code and to obscure physically uninteresting aspects of the program. We discuss experiences from using these programming exercises freshman physics classes at OSU's Marion campus. In the future, we plan to assess learning gains quantitatively using an animated version of the Force Concept Inventory originally developed by M. Dancy.

CE05: 5:40-5:50 p.m. An Interactive Textbook on the Physics of Sound

Contributed – Kyle Forinash, Indiana University Southeast, School of Natural Sciences, New Albany, IN 47150; kforinas@ius.edu

Wolfgang Christian, Davidson College

The bulk of the information provided to students in most courses is static in nature, consisting of PDF or PowerPoint versions of lecture notes, sample tests, syllabus and supplementary material. This is in spite of a trend for more interactive teaching methods such as group work, online chats, clickers, and Socratic dialog to mention only a few. So are there ways to make the assigned reading material more interactive? In this talk we will demonstrate the features of an interactive book on the physics of sound, which we published recently on iTunes. This book was used this past semester in an introductory physics of sound class and uses interactive simulations, sound clips and YouTube links to present a much more interactive text to students.

Session CF: Jupyter: VPython/ GlowScript

Location: CC - Breakout 7
Sponsor: Committee on Undergraduate Education
Co-Sponsor: Committee on Educational Technologies
Date: Monday, July 24
Time: 4–6 p.m.

Presider: Aaron Titus

CF01: 4-4:30 p.m. The Architecture of Jupyter VPython

Invited – Bruce Sherwood, 2712 Edenridge Drive, High Point, NC 27265; bruce.sherwood@gmail.com

Ruth Chabay, High Point University

Jupyter VPython (vpython.org) makes it easy to display real-time navigable 3D animations in a Jupyter notebook, which is an increasingly popular programming environment for Python users, including computational scientists and students in advanced computational physics courses. The VPython program running in a local server sends instructions to the notebook, running in a browser, to create or modify a 3D object. These instructions are passed to the GlowScript graphics library (glowscript.org), which uses the GPU-based WebGL library that is built into current browsers. Examples of Jupyter VPython capabilities will be shown.

CF02: 4:30-5 p.m. Jupyter VPython Visualization in Quantum Mechanics

Invited – Steve Spicklemire, University of Indianapolis, 1400 E Hanna Ave., Indianapolis, IN 46219; spicklemire@uindy.edu

Jupyter VPython is presented as a platform that enables students to engage in computational thinking and visualization of quantum theory using projects aligned with what might otherwise be a purely analytical course. Quantum Mechanics is a particularly difficult subject for students in part because of its inherently abstract mathematical formalism. Jupyter VPython projects allow students to "play" with the math computationally and to visualize what the math is saying in a way that's simply not possible without a computer. A novel 3-D representation of 1-D complex wavefunctions is described and multiple examples of its use in student projects will be demonstrated.

CF03: 5-5:30 p.m. Python Across the Curriculum: From Glowscript to Jupyter and Beyond

Invited – Matthew Craig, Minnesota State University Moorhead, 1104 7th Ave. S, Moorhead, MN 56563-2996; mcraig@mnstate.edu

The introductory calculus-based physics course at Minnesota State University Moorhead uses glowscript vpython. Later courses, including a computational physics course, use python, and some faculty use Jupyter notebooks for research. This talk provides an overview of how the department uses python and Jupyter notebooks, and the reasons notebooks are challenging for novice programmers. We will cover the transitions from glowscript vpython, to writing python files that are run in a command-line interpretor using Spyder, to using notebooks. We will include some suggestions for best practices to use in glowscript to make the transitions easier. A couple of promising options for using notebooks without a local python installation that are free and low-effort will also be discussed.

CF04: 5:30-5:40 p.m. Electronic Laboratory Notebooks Using Jupyter Notebook

Contributed – Alan J. DeWeerd, University of Redlands, 1200 E Colton Ave., Redlands, CA 92373-0999; alan_deweerd@redlands.edu

Students in the upper-division electronics course at the University of Redlands have been keeping electronic laboratory notebooks using Jupyter Notebook. The training and resources provided to help students include equations, figures, and graphs in their notebooks will be discussed. Student feedback about the use of electronic notebooks will also be presented.

CF05: 5:40-5:50 p.m. Interactive Visualizations with Jupyter/ GlowScript for Quantum Mechanics Courses

Contributed Craig C. Wiegert, University of Georgia, Dept of Physics and Astronomy, Athens, GA 30602-2451; wiegert@physast.uga.edu

Jupyter notebooks with GlowScript can help students visualize and manipulate quantum mechanical model systems, using free/open-source tools with simulation capabilities comparable to products like Mathematica. The visible running code in the notebook encourages tinkering and modification. I will demonstrate some of the Jupyter/GlowScript notebooks that I use when discussing topics such as Rabi flopping, the variational method, and time-dependent perturbation theory.

Session CG: Panel – New Developments in Introductory Physics for Life Science Dissemination

Location: Marriott - Covington Ballroom II
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 24
Time: 4–6 p.m.

Presider: Nancy Beverly

CG01: 4-4:30 p.m. IPLS-Portal: Resources for Faculty Professional Development

Panel – Juan Burciaga, Bowdoin College. Dept. of Physics and Astronomy, 8800 College Station, Brunswick, ME 04011-8448; jburciag@bowdoin.edu

IPLS-Portal represents a fundamental rethinking of how we as a community develop, test and disseminate curricular materials. One key element of IPLS-Portal is that faculty in IPLS courses will be active users, developers and reviewers of new curricular packages. But how do faculty take the step from preparing course materials for their own courses to developing curricular materials for the IPLS community? How do faculty critically, effectively evaluate the scholarship of others in a way that advances teaching/learning in IPLS courses? How do curricular developers submit their materials and receive feedback from the community? The talk will focus on a general overview of the IPLS-Portal in terms of motivation, resources for developers/users/reviewers, and the review process.

CG02: 4:30-5 p.m. Designing an Online Portal for Introductory Physics for Life Sciences

Panel – Mathew Martinuk, Theresa Neil Strategy + Design, 4806 Avenue H, Austin, TX 78751; sandy@strategyplusdesign.com

Educators routinely use the internet to search for teaching resources. However it's often difficult to find resources that fit their own class and students. Many excellent resources are held in specialized databases that are hard to find and harder to use, and conversely many curriculum developers have spent a lot of time developing databases that sit silent. These challenges are especially dire for IPLS educators due to specialized topics, diverse student populations, and the need for supplementary information on life sciences topics. In this talk we'll give an overview of how IPLS Portal is deploying a user-centered design process to build an online database of relevant IPLS resources and a community of educators and contributors. We'll give an overview of the planned portal components, and share some ideas on models for nucleating and nurturing contribution and community.

CG03: 5-5:30 p.m. Supporting Community Interactions Within and Around the IPLS Portal

Panel – Chandra Turpen, University of Maryland, 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu

Remy Dou, University of Maryland

Adrian Madsen, American Association of Physics Teachers

Although high-quality curricula exist and faculty are largely aware of them and motivated to try them, faculty use is not pervasive. Prior work has established that faculty often do not persist in using curricula due to challenges implementing them and issues determining if their instruction is working. These needs, concerns, and struggles of faculty inform our team's design of social experiences within and around the IPLS Portal. From a Vygotskian perspective, the portal's social artifacts and social organization will enable and constrain possibilities for collective learning. In this presentation, I will describe our team's preliminary research findings on where, when, and for what purposes faculty seek out other people for accomplishing tasks around the planning, designing and teaching of IPLS courses. Understanding circumstances that encourage faculty to pursue collaborations helps us develop an account of how the world is now from the vantage point of physics faculty and informs our dreaming and designing about how the world could be.

CG04: 5:30-6 p.m. IPLS- Portal: An Online, Open-source, Peer-reviewed Collection of Teaching Materials

Panel – Mark Reeves, George Washington University, Stoughton Hall, Department of Physics, Washington, DC 20052; reevesme@gwu.edu

The IPLS-Portal will be a website that combines already existing materials from multiple NSF-funded projects with a structure that allows developers to submit new work for peer review, evaluation, and inclusion. Its course-building interface will allow instructors to create innovative and individualized courses tuned to their needs, mixing and matching from multiple sources, contents, and pedagogies. For it to serve a spectrum of user communities who teach life science students, types of users must be identified and their needs must be represented in the structure and content of the portal. We will describe research and present preliminary results from surveys, focus groups, and site visits that have framed the initial conception of the portal. The broader community will be invited to participate in upcoming research to iteratively improve the portal to create a resource that will enable instructors to create and improve their IPLS courses easily and effectively.

Session CH: Inclusion and Equity

Location: CC - Breakout 9
Sponsor: AAPT
Date: Monday, July 24
Time: 4–5:20 p.m.

Presider: Mary Patton

CH01: 4-4:10 p.m. Fixed and Growth Mindset in Physics Graduate Admissions*

Contributed – Rachel E. Scherr, Seattle Pacific University, 3307 Third Avenue West, Seattle, WA 98119; rescherr@gmail.com

Monica Plisch, American Physical Society

Theodore Hodapp, American Physical Society

We are conducting research to learn how physics faculty evaluate students for admission to their graduate program, especially how they evaluate members of underrepresented groups (women and racial/ethnic minorities). Admitting people to graduate school means judging the likelihood that they will successfully contribute to the research mission of the department and the field. This is a judgment of intellectual potential. Through analysis of faculty interviews, we find that many faculty seek to admit students that they judge to have innate physics talent; we interpret these faculty members as applying a "fixed mindset," in which intelligence is understood as an inherent capacity or potential. An alternative is for faculty to seek to admit students who they believe can grow into physics achievement with effort; we interpret these faculty members as applying a "growth mindset," in which intelligence is understood in terms of acquired knowledge and effort. These two mindsets are associated with markedly different admissions practices. Cultivating a growth mindset in faculty might promote equity in graduate admissions.

*This material is based upon work supported by National Science Foundation Grant No. 1143070.

CH02: 4:10-4:20 p.m. Impact of Learning Assistants on First Generation Students' Success

Contributed – Jessica Deane, 712 Cedar Ct., New Brunswick, NJ 08901; jessicadeane09@gmail.com*

Diane Jammula, Rutgers University Newark

First generation students, i.e. students whose parents did not complete a four-year college degree, are a growing demographic at universities. The status of "first gen" often intersects with marginalized racial, ethnic, and class identities due to persistent barriers to higher education. Academic programming is typically designed for students of a dominant social and cultural background. This puts first gen students at a disadvantage. This case study explores the experiences of first-generation STEM majors enrolled in an introductory physics course with Learning Assistants at a minority serving institution. The research questions were: 1) How can LA support be characterized from students' perspectives? 2) What impact do LAs have on first-generation STEM majors, from their viewpoints? 3) What additional supports do first-generation STEM majors need and want? Interviews were analyzed using open coding. Findings discuss themes with implications for how to better support first-generation students in STEM.

*Sponsored by Dr. Diane Jammula

CH03: 4:20-4:30 p.m. Inequitable Physics: Developing Curricula to Emphasize a Need for Change

Contributed – Sierra R. Decker, Seattle Pacific University, 3018 4th Ave W, Seattle, WA 98119; deckers@spu.edu

Abigail R. Daane, Seattle Pacific University

In an introductory university physics course, we taught a unit about racial inequity, explicitly highlighting the glaring underrepresentation of people of color and women in the physics community. The weeklong equity unit emphasizes that while physics is often described as objective and uninfluenced by racial and cultural differences, in reality, both current and future physicists are affected by their personal experiences. The development and teaching of physics is impacted by the people who participate (or do not participate) in the community, yet this issue has been left out of most physics curricula. We provide a description of an equity unit appropriate for introductory university physics that aims to increase awareness of racial inequity and empower students to become agents of change.

CH04: 4:30-4:40 p.m. Investigating Physics Faculty's Reasoning About Equity in Undergraduate Physics Education

Contributed – Chandra Anne Turpen, University of Maryland, 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu

Angela Little, University of Maryland and Michigan State University

We report on a pilot interview study to investigate how junior physics faculty reason about equity in the undergraduate physics student experience. In these interviews, we asked faculty about their knowledge of student experiences with bias, discrimination, and hardship. Faculty were also invited to reflect on the fairness of various common classroom instructional practices. There was a wide range of faculty background and experience in considering equity-related topics. Some faculty described employing innovative strategies to make their classroom environments more inclusive. Other faculty noted struggles with connecting the dots between diversity and research-based instructional practices, despite being on-board with both. The insights gained through this study suggest ways to infuse discussions of inclusive pedagogical practices into professional development focused on research-based instructional strategies.

CH05: 4:40-4:50 p.m. Measuring Equity in Small Groups

Contributed – Benjamin J. Archibeque, Kansas State University, 4631 S. Meridian, Wichita, KS 67217-3766; barchibeque1@ksu.edu

Florian Genz, University of Cologne

Eleanor Sayre, Kansas State University

Mary Bridget Kustusch, DePaul University

Scott Franklin, Rochester Institute of Technology

This project investigates how to measure equity in small student groups. We follow several student groups to operationalize how discourse may be equitable or inequitable. The groups came from the IMPRESS program, a two week, pre-college program that prepares first generation and deaf/hard-of-hearing students to major in a STEM field. At IMPRESS students focus on improving their metacognitive skills and cultural preparation for college life within a context of model building. We use three methods to measure equity. First, we look at speaking time: who talks, when, and to whom. Second, we look for moments when individuals are included or excluded and the prevalence of those moments. Third, we look at the comparative "inchargeness" – how much control an individual has over the direction of conversation – of the group members. We compare all three methods to see how effective and consistent they are at capturing equity in group's discourse.

CH06: 4:50-5 p.m. Researching Emotional Classroom Discourse on Race

Contributed – Katelin Corbett, The Graduate Center, CUNY, 365 5th Ave., New York, NY 10016; katelin.corbett@gmail.com

Konstantinos Alexakos, Brooklyn College, CUNY

Content in teaching and learning is only one component of the knowledge produced and/or reproduced as part of a classroom experience. These other experiences are inevitable and essential aspects of formal education, but are often overlooked because they are difficult to simply reduce to data or quantify. The research presented will be based on a personal narrative by a participant in the class who was also a researcher, student and a co-teacher in the course. It will explore the emotions (hers and of other participants) that emerged during a discussion on the Alton Sterling shooting in Baton Rouge, Louisiana in the summer of 2016 in a physics class for graduate inservice and preservice teachers.

CH07: 5-5:10 p.m. Scientific Inquiry: Let's Discuss Diversity and Inclusion in STEM

Contributed – Carolina Alvarado, California State University Chico, Department of Physics, 400 West First Street, Chico, CA 95929; calvarado-leyva@csuchico.edu

The Next Generation Science Standards, the current guidelines for K-12 science instruction, establishes both the content to be covered and the scientific practices students should engage in. In this investigation, we explored how in a course for pre-service teachers on scientific inquiry the activities designed to develop evidence-based argumentations skills can also be used to trigger conversations about the lack of diversity in STEM fields. We leveraged students' abilities to engage in evidence-based scientific practices developed in class as well as being able to respond to counter-arguments while discussing the data provided and make an interpretation. The aim of this presentation is to begin a conversation about data-based strategies to create a dialog on inclusive teaching strategies.

CH08: 5:10-5:20 p.m. Researching Emotional Classroom Discourse on Race

Contributed – Katelin Corbett, The Graduate Center, CUNY, 365 5th Ave., New York, NY 10016; katelin.corbett@gmail.com

Konstantinos Alexakos, Brooklyn College, CUNY

Content in teaching and learning is only one component of the knowledge produced and/or reproduced as part of a classroom experience. These other experiences are inevitable and essential aspects of formal education, but are often overlooked because they are difficult to simply reduce to data or quantify. The research presented will be based on a personal narrative by a participant in the class who was also a researcher, student and a co-teacher in the course. It will explore the emotions (hers and of other participants) that emerged during a discussion on the Alton Sterling shooting in Baton Rouge, Louisiana in the summer of 2016 in a physics class for graduate inservice and preservice teachers.

Session CI: Introductory Courses

Location: CC - Breakout 10
Sponsor: AAPT
Date: Monday, July 24
Time: 4–6 p.m.

Presider: Richard Price

CI01: 4-4:10 p.m. The Joy of an Experiential Final Exam

Contributed – Donald Andrew Smith, Guilford College, 5800 W. Friendly Ave., Greensboro, NC 27410; dsmith4@guilford.edu

I present an alternate approach to an introductory undergraduate physics final examination. Instead of requiring students to demonstrate what they have learned through written articulation of their solutions to word problems, I have tried in several classes (including a new IPLS course) asking students to demonstrate their knowledge gain by tackling a simple experiment, in a small group, that demands understanding of course topics, but not an experiment they have seen. Students have 90 minutes to complete the experiment, and then they report on their findings for the last hour of the exam through ten-minute oral presentations. I will explain how I organized the exam and give examples of student work. Students reacted very positively to this kind of exam, showing enthusiasm, engagement, and creativity. I will reflect on the strengths and weaknesses of this approach for different populations of introductory physics students.

CI02: 4:10-4:20 p.m. The Class Story

Contributed – Carolyn M. Martsberger, Wofford College, 429 N Church St., Spartanburg, SC 29303; martsbergercm@wofford.edu

Newton's three laws provide the foundation for an introductory physics course. However, the third law often confuses students and can challenge their understanding of laws one and two. In this talk, I will introduce an interactive in class activity that will articulate the differences between Newton's second and third law. This activity will lead to the development of a class story that can be recalled throughout the semester to help students differentiate between what forces an object exerts on its environment versus the forces that are applied to an object. The activity is applicable to large or small class sizes. Furthermore, the story creation portion promotes team building skills and solidifies a positive class culture at a time in the semester where students are becoming connected with their physics community and invested in the course itself.

CI03: 4:20-4:30 p.m. Amusement Park Data Collection with an Arduino

Contributed – Timothy A. Stiles, Monmouth College, 700 E Broadway Ave., Monmouth, IL 61462; tstiles@monmouthcollege.edu

As part of a three-week summer research program, undergraduate students designed and built Arduino-based data collection devices. Each device included a three-axis accelerometer, three-axis gyroscope, three-axis magnetometer, barometric pressure sensor (used to record altitude), and GPS receiver to record position. These devices were tested on playground equipment and then used at an amusement park to record the acceleration, rotation rate, orientation, and position while on the rides. These devices have several advantages over commercial systems. The ability to record rotation, orientation, and position allows for a more thorough investigation into the physics of the amusement park ride. The sensors (other than GPS) can operate at 100 Hz and record data very quickly to an SD card. The overall cost of each device is $150. Results from the rides were aligned with video from the ride to provide a visual representation of the forces acting on the riders. Results will be available publicly for use in high school or undergraduate courses at other institutions.

CI04: 4:30-4:40 p.m. EPA Mileage – Curb Weight Internet Activity for Introductory Physics

Contributed – Brenda M. Skoczelas, Lake-Sumter State College, 9501 U.S. Hwy 441, Leesburg, FL 34788; Skoczelb@lssc.edu

David R. Ober, Ball State University

Two two-hour laboratory periods are used to provide students with an opportunity for collaborative learning and making professional meeting-type presentations of data. Students will first work in partners and use the internet to research technical information on vehicle Fuel Economy ratings and Curb Weight for a variety of EPA Class Sizes. This is an important topic that is relevant to any person that might be looking to purchase a vehicle. Each group's small data sets will then be shared with all groups in much the same way that real scientists communicate findings. During the second week, groups will organize a larger set of data, draw conclusions, set up mathematical relationships in many different ways, and present their findings in a professional meeting format. In this activity, students will have a chance to apply their textbook physics concepts to explain the real world relationships.

CI05: 4:40-4:50 p.m. Comparing Jumping Rings Powered with AC and DC

Contributed – Rondo N. Jeffery, Weber State University, 4521 S 1650 W, Roy, UT 84067; rnjeffery@msn.com

Farhang Amiri, Weber State University

The DC powered jumping ring was discussed in a recent TPT article (Feb. 2016, pp. 112-16). In the impulse stage, the ring lifts first on the side closest to the iron core. This is highly suggestive that it is the Lorentz force that acts on the ring to give it lift. With AC power, if the ring moves over the coil as well as the iron core, the force decreases towards the middle of the coil. If the ring is placed on the iron core with DC applied, it falls at constant velocity. With AC power applied, a ring placed on the iron core will float or levitate, showing there is a non-zero time-averaged upward force over the full AC cycle. This requires a finite phase shift of ring current with respect to the induced Emf (cf. TPT Sept. 2008, pp. 350-57). There is no phase shift for the DC powered ring.

CI06: 4:50-5 p.m. Some Surprising Facts About Heat Transfer Through a Window

Contributed – A. James Mallmann, Milwaukee School of Engineering, 20250 W Jeffers Dr., New Berlin, WI 53146-2522; mallmann@msoe.edu

I will present examples of common errors in and incomplete treatment of end-of-chapter textbook problems involving heat transfer through a window. I will also tell about a puzzle I present to my students for which they suffer from the idea that: A little knowledge is a dangerous thing. The solution to that puzzle is a guide to design of high quality windows.

CI07: 5-5:10 p.m. Remembering the S.S. Edmund Fitzgerald

Contributed – Gregory A. DiLisi, John Carroll University, 1 John Carroll Blvd., University Hts., OH 44118; gdilisi@jcu.edu

Richard A. Rarick, Cleveland State University

November 10, 2015 marked the 40th anniversary of the sinking of the S.S. Edmund Fitzgerald, a Great Lakes bulk cargo freighter that suddenly and mysteriously sank during a severe winter storm on Lake Superior. With this presentation, we describe how we commemorated the anniversary of this tragedy by bringing it to the attention of a new generation of students, namely those enrolled in our introductory physics courses. Since most of our students were not yet born when the ship sank, we first established a historical context for them by providing detailed information about the ship's final voyage and wreckage site. We then focused on "rogue waves" and the principle of superposition to produce a simple simulation of the conditions that might have resulted in the giant freighter's sudden sinking.

CI08: 5:10-5:20 p.m. Setting the Academic Bar for IPLS Students

Contributed – Duane L. Deardorff, The University of North Carolina at Chapel Hill, Campus Box 3255, Chapel Hill, NC 27599-3255; duane.deardorff@unc.edu

Alice D. Churukian, Colin S. Wallace, Laurie E. McNeil, The University of North Carolina at Chapel Hill

David P. Smith, University of Washington

Instructors of introductory physics for the life sciences (IPLS) need assessment questions that 1) probe students' physics fluency at an appropriate level, 2) present authentic applications of physics for the life sciences, and 3) engage students' higher-order thinking skills. Developing questions that satisfy these requirements is non-trivial. In this talk, we will share a sample of assessment questions we have created and utilized in the two-semester IPLS sequence at UNC-Chapel Hill. We will describe how these questions meet the above criteria and report on student performance.

*This work has been supported in part by the National Science Foundation under Grant No. DUE-1323008 and AAU Undergraduate STEM Education Initiative.

CI09: 5:20-5:30 p.m. Successes & Challenges in Transitioning to Large Enrollment NEXUS/Physics IPLS Labs

Contributed – Kimberly A. Moore, University of Maryland, 6525 Roosevelt St., Falls Church, VA 22043; MoorePhysics@gmail.com

UMd-PERG's NEXUS/Physics for Life Sciences laboratory curriculum, piloted in 2012-2013 in small test classes, has been implemented in large-enrollment environments at UMD from 2013-present. These labs address physical issues at biological scales using microscopy, image, and video analysis, electrophoresis, and spectroscopy in an open, non-protocol-driven environment. We have collected a wealth of data (surveys, video analysis, etc.) that enables us to get a sense of the students' responses to this curriculum in a large-enrollment environment and with teaching assistants both 'new to' and 'experienced in' the labs. In this talk, we will provide a brief overview of what we have learned via student perception then and now using a variety of comparisons of our large-enrollment results to the results from our pilot study. We will close with a discussion of the acculturation of teaching assistants to this novel environment and suggestions for sustainability.

CI10: 5:30-5:40 p.m. Teaching Thermodynamics to Life Science Students Using Osmosis

Contributed – Peter Hugo Nelson, Guilford College, 4512 Grendel Rd., Greensboro, NC 27410; pete@circle4.com

A solute-blocking model has recently been published that provides a kinetic explanation of osmosis and ideal solution thermodynamics. While it directly contradicts current physics textbooks, it provides theoretical support for the descriptive explanation found in most life science and chemistry textbooks. It validates a diffusive model of osmosis that is distinct from the traditional convective flow model of osmosis. Osmotic equilibrium occurs when the fraction of water molecules in solution matches the fraction of pure water molecules that have enough energy to overcome the pressure difference. Solute-blocking also provides a kinetic explanation for why Raoult's law and the other colligative properties depend on the mole fraction (but not the size) of the solute particles, resulting in a novel kinetic explanation for the entropy of mixing and chemical potential of ideal solutions. http://rdcu.be/nify

CI11: 5:40-5:50 p.m. Incorporating Computation into a Physics Course for Life Science Students

Contributed – Vashti A. Sawtelle, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824-2320; vashti.sawtelle@gmail.com

Introductory Physics for the Life Sciences (IPLS) courses are gaining momentum in the physics education community, with the creation of multiple curricula for a variety of implementation strategies. At Michigan State University, we have designed an integrated lab-lecture (studio style) introductory physics course that meets the needs of life science students. Our design of this course focuses on incorporating computational simulations that model complex biological phenomenon. We will present on a unit on diffusion in which we incorporated a series of computational tasks designed to build up students' understanding of collisions and random motion. Our research investigates how this focus supports students in seeing physics as a relevant to the biology they care about.

CI12: 5:50-6 p.m. Realistic Problems in Electrostatics for the Life Sciences

Contributed – Ulrich Zurcher, Cleveland State University, 2121 Euclid Ave., Cleveland, OH 44115; u.zurcher@csuohio.edu

Redish and collaborators make a compelling case to include chemical energy in the introductory physics course for the life sciences [AJP 82, 403 (2014)]. Chemical energy is partially due to electrostatic interactions between ions and molecules. We discuss how relatively simple examples from chemistry can be used to give students a sense of the order of magnitude of the electrostatic interactions. We discuss the water dimer to discuss hydrogen boding [Eur. J. Phys 38, 015206(2017) and the interaction of a diatomic molecule [HCl] to discuss oscillations relevant for vibrational spectroscopy. We use kJ/mol and kJ/mol/A for the units of energy and force.

Session CJ: PER: Student Reasoning

Location: CC - Ballroom C
Sponsor: AAPT
Date: Monday, July 24
Time: 4–5:50 p.m.

Presider: Beverly Cannon

CJ01: 4-4:10 p.m. University Student Conceptual Resources for Understanding Forces*

Contributed – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave. W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu

Lisa M. Goodhew, Paula R L Heron, University of Washington

Rachel E. Scherr, Seattle Pacific University

Large-scale research on student ideas has historically tended to report the common incorrect ideas – often called misconceptions – that students use in answering physics questions. Our work takes a different approach: we are analyzing large numbers of student written responses to identify and understand the resources – or the productive "beginnings" of physics understandings – that students bring to bear in their reasoning about forces and that instructors can build on in instruction. This talk will share some examples of university student conceptual resources for understanding forces that we have identified in our preliminary analysis.

*This work is supported in part by NSF DUE 1608510.

CJ02: 4:10-4:20 p.m. University Student Conceptual Resources for Understanding Mechanical Waves

Contributed – Lisa M. Goodhew, University of Washington 3910 15th Ave NE, Seattle, WA ; goodhewl@uw.edu

Amy D. Robertson, Rachel Scherr, Seattle Pacific University

Paula R. L. Heron, University of Washington

Instruction grounded in a resources theory of knowledge—in which students' intuitive knowledge is viewed as potentially productive and as a basis for instruction—has the potential to promote learner agency, support students from diverse backgrounds, and enhance conceptual understanding. We present our analysis of written responses to conceptual questions about mechanical waves, given to students at multiple institutions across the United States. This analysis focuses on the common, productive ideas – or the resources – that students use to reason about mechanical waves, with an eye toward how they can inform instruction. In particular, we not only discuss what students' common, productive ideas are, but how they are productive and in what ways they might be taken up in instruction.

CJ03: 4:20-4:30 p.m. Investigating Less Common Ideas About Force and Motion

Contributed – Trevor I. Smith, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028-1701; smithtr@rowan.edu

Students often claim (either explicitly or implicitly) that the net force on an object is proportional to its velocity. This result is clearly seen in studies involving student responses to the Force and Motion Conceptual Evaluation (FMCE); however, the FMCE provides students with at least seven answer choices for each question asking them to select a force that would cause a given motion. Our previous results have shown that a non-trivial number of students choose a response that does not align with either the correct or the most-common-incorrect model. Many of these answer choices are consistent with previously documented student ideas (such as reading a graph as a picture of a situation), but they have not been explicitly connected. We present results from surveys that show the prevalence of these responses across different student populations, and from student interviews designed to clarify students' reasons for choosing each.

CJ04: 4:30-4:40 p.m. Modeling Student Understanding of Period, Frequency, and Angular Frequency

Contributed – Nicholas T. Young, The Ohio State University, 134 West 9th Avenue, Apt B, Columbus, OH 43201; young.1905@osu.edu

Andrew F Heckler, The Ohio State University

Periodic behavior is a fundamental phenomenon in many physical systems; therefore, it is critical that students understand the concepts and relationships that underlie such behavior. Here, we used the context of the behavior of a simple harmonic oscillator to investigate students' ability to determine the period, frequency, and angular frequency from various mathematical and graphical representations by administering a 36-item test to students in an introductory-calculus-based physics course. We found that students could be classified into one of four groups, according to the question types they mastered. These groups were hierarchically categorized based on the number and kind of relationships each student mastered. For example, we found only students who could correctly apply the period and frequency relationship could also correctly apply any angular frequency relationship. This hierarchical nature of student performance suggests instruction should focus on ensuring that students understand the period and frequency relationship before introducing angular frequency.

CJ05: 4:40-4:50 p.m. Student Understanding of Events and Causality in Special Relativity

Contributed – Alexis RW Olsho, University of Washington, 523 Broadway E #663, Seattle, WA 98102; arwo@uw.edu

Peter S. Shaffer, University of Washington

Special relativity is one of several topics that are commonly taught at the introductory level as a way of illustrating the limitations of classical mechanics. The relativity of simultaneity provides a particularly rich context, as it can be reasoned about entirely qualitatively (i.e., without the Lorentz transformations). It can therefore be used both to teach and assess student conceptual understanding of several key ideas in Galilean and special relativity, and physics in general. Student understanding of one of these ideas, causality, will be discussed.

CJ06: 4:50-5 p.m. Teaching Assistants' Performance at Identifying Common Introductory Student Difficulties in Electricity and Magnetism Revealed by the Conceptual Survey of Electricity and Magnetism

Contributed – Nafis Karim, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; nafis.ru@gmail.com*

Alexandru Maries, University of Cincinnati

Chandralekha Singh, University of Pittsburgh

We discuss research involving the CSEM to evaluate one aspect of the pedagogical content knowledge of teaching assistants (TAs): knowledge of introductory students' alternate conceptions in electricity and magnetism as revealed by the CSEM. For each item on the CSEM, the TAs were asked to identify the most common incorrect answer choice of introductory physics students. This exercise was followed by a class discussion with the TAs related to this task, including the importance of knowing student difficulties in teaching and learning. Then, we used CSEM post-test data from approximately 400 introductory physics students (provided in the original paper describing the CSEM) to assess the extent to which TAs were able to identify alternate conceptions of introductory students related to electricity and magnetism. In addition, we carried out think-aloud interviews with graduate students who had more than two semesters of teaching experience in recitations to examine how they reason about the task. We find that while the TAs, on average, performed better than random guessing at identifying introductory students' difficulties with CSEM content, they did not identify many common difficulties that introductory physics students have after traditional instruction. We thank the National Science Foundation for support.

*Sponsored by Chandralekha Singh

CJ07: 5-5:10 p.m. Physical Science Teachers' Resources for Accelerated Motion*

Contributed – Elijah Tabachnick, University of Maine, 5709 Bennett Hall, Orono, ME 04469-5709; elijah.tabachnick@maine.edu

Peter Colesworthy, Michael C. Wittmann, University of Maine

The terms "speeding up" and "slowing down" are often equated with positive and negative acceleration, respectively; we refer to this as the speed model of acceleration. As part of the Maine Physical Sciences Partnership, we have investigated middle school physical science teachers' understanding of accelerated motion in the context of using vectors as a pictorial tool for kinematics and found high prevalence of the speed model. One aim of our work is to address the speed model of accelerated motion. Through observation of professional development activities, interviews, and surveys, we have found that the teachers consistently use the correct mathematical tools to talk about displacements and velocities, and correctly use vectors to represent displacements, velocities and accelerations. However, when interpreting the acceleration of an object, teachers often use the speed model, which contradicts their other work. We discuss this result and its possible origin

*Supported in part by NSF MSP 0962805.

CJ08: 5:10-5:20 p.m. Student Data Suggest Teachers Need a Resources-based Model of Eenergy*

Contributed – Michael C. Wittmann, University of Maine, 5709 Bennett Hall, Orono, ME 04469-5709; mwittmann@maine.edu

Adam Z. Rogers, Laura Millay, University of Maine

Carolina Alvarado, California State University - Chico

One power of middle school physics teaching is its focus on conceptual understanding, rather than mathematical modeling. Teaching energy in middle school allows one to focus on the conceptual ideas, metaphors, and analogies we use to make sense of a topic that, in the Next Generation Science Standards, is both a core disciplinary idea in the physical sciences and a crosscutting concept. In this talk, we provide several examples of seeming contradictions in student responses to similar questions. For example, students think differently about energy flow to the air or the ground. They also think differently about energy flow in cold (not hot) situations, depending on whether a human is part of the problem. Analyzing these results from a resources-based perspective may help both researchers and teachers listen for ideas, target instruction, and recognize learning.

*Supported in part by NSF MSP 0962805 and DRL 1222580

CJ09: 5:20–5:30 p.m. Deep Learning in Introductory Physics: Studies of Model-Based Reasoning

Contributed – Mark J. Lattery, University of Wisconsin Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54902-6945; lattery@uwosh.edu

In light of the emphasis on scientific models and modeling in the Next Generation Science Standards (NGSS), a growing number of education researchers are engaged in the broad question of how students learn science in a model-centered classroom. The diverse, creative, and sometimes unexpected ways students construct models, and deal with intellectual conflict, provide valuable insights into student learning and cast a new vision for physics teaching. This presentation explores the hypothesis that deep learning in introductory physics is regressive. *

*For further discussion, see Lattery, M. (2017). Deep Learning in Introductory Physics: Exploratory Studies of Model-Based Reasoning (NC: Information Age Publishing) and the LPEER Group research and teaching site: www.lpeerg.com. This research project was supported in part by the Spencer Foundation (#200800161), University of Wisconsin System (#106-01-7000-2), and University of Wisconsin Oshkosh Faculty Development Board.

CJ10: 5:30-5:40 p.m. Developing Research Assessments for the Next Generation of Student Learning

Contributed – James T. Laverty, Kansas State University, 1228 N. 17th St., Manhattan, KS 66502; laverty@ksu.edu

Brett R. Kippley, Kansas State University

Recent calls for the transformation of science education elevate the process of science (scientific practices) to the same level of importance as the content of science (core ideas). Before we can begin to determine the success of these transformations, we must be able to assess practices and core ideas. The 3D-LAP is a protocol that can help us develop assessment tasks that have the potential to elicit evidence that students have engaged in scientific practices and core ideas, but more work is needed to understand how we can assess these constructs rigorously enough for research. We are developing an assessment to investigate what students are currently learning in terms of using scientific practices with core ideas. The development of this assessment brings new challenges that will be examined and discussed.

CJ11: 5:40-5:50 p.m. Participation Rates of In-class vs. Online Administration of Concept Inventories and Attitudinal Assessments

Contributed– Xochith M. Herrera, CSU Chico, 1080 columbus Ave., apt 1, Chico, CA 95926; xochithh@gmail.com

Manher Jariwala

Jayson Nissen, Ben Van Dusen, CSU Chico

Eleanor Close

We investigated differences in student participation rates between in-class and online administrations of the Force Concept Inventory (FCI), Conceptual Survey of Electricity and Magnetism (CSEM), and the Colorado Learning Attitudes about Science Survey (CLASS). 1,645 students from three introductory physics courses over two semesters were instructed to complete the CLASS and the concept inventory relevant to their course, either the FCI or CSEM. We randomly assigned each student to take one of the instruments in class and the other instrument online using the LA Supported Student Outcomes (LASSO) platform at the beginning and end of the course. Results indicated large variation in participation rates across both test conditions (online vs. in class). We will discuss the implications for measuring changes in students' knowledge and attitudes using the two different methods for administering the research instruments.

Session CK: PER: Evaluating Instructional Strategies

Location: CC - Ballroom D
Sponsor: AAPT
Date: Monday, July 24
Time: 4–5:50 p.m.

Presider: Jay Wang

CK01: 4-4:10 p.m. Snapshots of Studio Physics Classrooms Across Universities

Contributed – Jacquelyn J. Chini, University of Central Florida, 4111 Libra Drive - PSB 430, Orlando, FL 32816; jchini@ucf.edu

Matthew Wilcox, University of Central Florida

Noel Klingler Gerald Feldman, George Washington University

Joshua S. Von Korff, Georgia State University

An increasing number of institutions are adopting a collaborative student-centered studio approach for their introductory physics classes, with many adopting a SCALE-UP approach. The FAQ at scaleup.ncsu.edu explains that students work in teams on "short, interesting tasks" and warns the instructor "if you are lecturing for more than 15 minutes, you are probably talking too much." So, how are students and instructors in studio courses spending their in-class time? We have used a modified version of the Teaching Dimensions Observation Protocol (TDOP) to characterize instruction at nine universities with more than 40 instructors. The modified TDOP identifies different types of instructor dialogue, class discussion and students' group and individual work, as well as technology used in the classroom. We will discuss similarities and differences at the institution and instructor level for frequency of code occurrence and common code combinations.

CK02: 4:10-4:20 p.m. Interventions Using Worked Synthesis Problems: Comparing Analogical Reasoning vs. Self-Summary

Contributed– Ryan C. Badeau, Dept. of Engineering Education; The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210-1168; ryan.badeau@gmail.com

Daniel White

Bashirah Ibrahim, Lin Ding, Andrew F. Heckler, The Ohio State University

The ability to solve physics problems that require multiple concepts from across the physics curriculum, or "synthesis" problems, is often a goal of physics instruction. In previous work we found that such problems represent unique challenges to students beyond single-concept mastery - in particular, student difficulty with simultaneous concept recognition and joint application. Here, we report a follow-up study with calculus-based introductory physics students in which student performance on a target synthesis problem was compared after training via either self-summary of worked synthesis examples or guided analogical comparisons. Both interventions significantly increased student performance on the target problem compared to no-training control. However, there is evidence for interaction with student aptitude and time-on-task across conditions. Additionally, student responses to the training show differences in the frequency and type of student difficulties; these may suggest principles to anticipate where each intervention may be beneficial on other, novel synthesis problems.

CK03: 4:20-4:30 p.m. Interviews About Research-based Physics Activities

Contributed – Joshua S. Von Korff, Georgia State University, 25 Park Place, suite 605, Atlanta, GA 30350; jvonkorff@gsu.edu

Amin Bayat Barooni, Monica Cook, Kyle Simmons, Georgia State University

Many research-based activities have been designed over the past several decades; these include the Tutorials in Introductory Physics, Realtime Physics, Workshop Physics, several Investigative Science Learning Environment products, Tutorials in Physics Sensemaking, Modeling Instruction labs, and others. However, for a variety of reasons, many instructors still design their own activities, and they may want to imitate the accomplishments of experienced physics education researchers. We have interviewed authors of these activities to find out about their design strategies and motivation behind the design of the activities. This project will help instructors to imitate research-based activities and may also help the PER community to articulate the purpose of the activities to instructors. We have coded and analyzed the authors' comments.

CK04: 4:30-4:40 p.m. Team-based Learning in Large-Enrollment, Introductory Courses

Contributed – Laura J. Tucker, University of California, Irvine, 4129 Frederick Reines Hall, Irvine, CA 92697-4575; tucker@uci.edu

Team-based learning uses assigned, fixed teams as a core component of the course structure. In very large introductory courses with up to 400 students, administration and classroom structure are expected hurdles to this pedagogy. We discuss multiple implementations of team-based learning with team-based (IF-AT) exams in these courses, and present data on student outcomes and student response to this pedagogy.

CK05: 4:40-4:50 p.m. Adapting Interactive Tutorials for Large-scale Algebra-based Classes

Contributed – Ryan L C Hazelton, University of Washington, Department of Physics, Box 351560, Seattle, WA 98115; rlhazelton@gmail.com

Much of the PER-based curricular materials have been developed in the context of small-group sections with moderate enrollment; for example, Tutorials in Introductory Physics are designed to facilitate peer-instruction in classrooms with 20-30 students in the calculus-based introductory sequence. At the University of Washington the algebra-based courses are 200-600 students, with no small-group sections. However curricula like the Tutorials can be extremely successfully adapted for use in large-scale classes. Though some aspects of their use in small-group sections have to be modified or dropped when dealing with hundreds of students, these students show gains in understanding that are comparable to those of students in the calculus-based courses.

CK06: 4:50-5 p.m. Student's Learning Transformation via Ranking and Sensemaking Tasks in Introductory Physics Courses

Contributed – Orlando M. Patricio, Laredo Community College, 1 West End Washington St., Laredo, TX 78040; orlando.patricio@laredo.edu

Generation Z and millennial students have different learning styles and attention spans. The American Association of Physics Teachers (AAPT) recognized the need to improve student performance and transform the physics classrooms. About 25 physics educators were trained and immersed in using various innovative teaching strategies on the last cohort of an 18-month New Faculty Experience (NFE) for physics educators. Hence, this study is a result of this project. This research explored the transformational effect(s) of using ranking and sensemaking tasks/activities in introductory physics courses to student's (1) pre/posttest scores and (2) final exams. The student's portfolio of the activities were also assessed to ascertain their level of critical thinking skills. To gain better insights of the productive elements of the activities, student's journals and impressions were collected and analyzed. The activities were embedded in the usual classroom routine. The student's learning transformation is phenomenal. With permission from Pearson in using some Sensemaking and Ranking Tasks/Activities.

CK07: 5-5:10 p.m. Evaluating Modeling Instruction Curricular Changes by Students' Representation Choices

Contributed – Daryl McPadden, Florida International University, 2515 Van Buren Ave., Grand Junction, CO 81505; dmcpadden621@gmail.com

Eric Brewe, Drexel University

Representations (i.e., graphs, pictures, equations, etc.) are a foundational feature of the Modeling Instruction pedagogy and curriculum. Indeed, the first two steps of the modeling cycle in the class as introduced by Brewe (2008) are: 1) Introduction and Representation and 2) Coordination of Representations. Since representation use is one of the primary tenants of the course, we use the Problem Solving and Representation Use Survey (PSRUS) as a measure to evaluate curriculum changes in the Modeling Instruction – Electricity and Magnetism course between the spring 2015 and spring 2016 semesters. Using non-parametric frequentist statistics, we show the differences between the semesters in the number of representations that students are choosing, the types of representations that students are choosing, and the context that students find these representations relevant. Preliminary results suggest that the changes in curriculum increase the number and variety of representations students choose independent of context (particularly in verbal representations).

CK08: 5:10-5:20 p.m. Project BoxSand: Educational Data Mining and Student Web Behavior

Contributed – Kenneth C. Walsh, Oregon State University, 301 Weniger Hall, Corvallis, OR 97331-8507; walshke@physics.oregonstate.edu

Do students watch videos to prepare for a flipped classroom? When I decided to flip my classroom, I created a series of pre-lecture videos for content delivery. I also wanted to make my class completely open source. These two desires led me to create a website with all the best open resources we could find and some content we created ourselves. Students are guided through these resources with a Daily Learning Guide (DLG) and we track every mouse click. We look for correlations between use of the online resources and performance in the class, FCI gains, and surveys. Do students watch pre-lecture videos before class, before a midterm, or ever and does this correlate to performance in the class? Does following the DLG or going "off-road" have any effect on student outcomes? I will discuss a data set that includes ~ 1 million data points from roughly 450 students.

CK09: 5:20-5:30 p.m. Enhancing Measurement of Student Learning Through Online Instructional Design

Contributed – Zhongzhou Chen, University of Central Florida, 4111 Libra Drive, PSB 153, Orlando, FL 32828; Zhongzhou.Chen@ucf.edu

The latest online education platforms provide a rich variety of new instructional design options, inspiring novel online instructional designs that are drastically different from the traditional "lecture-homework-quiz" mode of brick-and-mortar courses. In this talk I will introduce such a new design that is aimed at improving the resolution of learning measurement in an online environment. By utilizing functionalities such as multiple attempts, problem banks, and control over content access, the new design enables effective pre-post testing on the scale of a single learning module that could be completed in less than an hour, a significant improvement over the traditional course structure that measures learning over the course of at least a week. Such high-frequency learning measurement will allow instructors to gain a more comprehensive understanding of student's learning process, and quickly evaluate the effectiveness of learning resources.

CK10: 5:30-5:40 p.m. Learning from Animated Video Solutions: Does Solving the Problem Matter?

Contributed – Jason W. Morphew, University of Illinois at Urbana-Champaign, 4112 Rayburn Ct., Champaign, IL 61822; jmorphe2@illinois.edu

Jose P. Mestre, Gary E. Gladding, University of Illinois at Urbana-Champaign

A common instructional practice is to provide feedback using video solutions on problems that students have first attempted to solve on their own. Attempting to solve problems may allow the student to focus on the aspects they don't know resulting in more productive learning. On the other hand, the increase in focus may inhibit learning from the other information presented in the video solutions. We present data where students in an introductory mechanics course were randomly assigned to either attempt-to-solve-first/not. Afterwards both groups viewed video solutions of the problems, and completed a post-test including similar and transfer problems. Confidence judgements were made after attempting each problem. Data will show whether or not attempting the problems prior to watching video solutions affects learning and metacognitive accuracy of their judgements of learning. We also discuss the educational implications of our findings.

CK11: 5:40-5:50 p.m. Exploring the Limits of Online Mastery-Style Activities

Contributed – Brianne Gutmann, University of Illinois - Urbana Champaign, 307 W Elm Street Apt 2, Urbana, IL 61801; bgutman2@illinois.edu

Timothy Stelzer, Gary Gladding, University of Illinois - Urbana Champaign

For the last three years, online mastery-style homework has replaced traditional online homework in a large preparatory physics course at the University of Illinois. Data driven changes have been effected over these years to improve the implementation so it best helps students succeed, and now we are interested in the limits of mastery-style delivery. By identifying specific levels that students struggle to complete, we can evaluate which types of problems are not well-suited for mastery. I will detail future plans to test an alternative delivery method for these problems, still alongside successful mastery levels.

Session CL: Being Disabled in Physics

Location: CC - Breakout 8
Sponsor: Committee on Professional Concerns
Co-Sponsor: Committee on Diversity in Physics
Date: Monday, July 24
Time: 4–5:40 p.m.

Presider: Rebecca Lindell

CL01: 4-4:30 p.m. My Journey: Student to STEM Professional

Invited – Shannon Dumphy Lazo, St. Louis, MO 63108

Budding STEM students with disabilities face additional challenges on the path through college and on to work. As a STEM Educator and Engineer, I will share my personal journey through undergraduate and graduate school and subsequent professional jobs with the Federal Government and the non-profit sector, all while fighting a neurodegenerative disorder. Learning about my challenges will hopefully help educators and professors understand, adapt and include disabled STEM students and professionals within the community. Thus creating a positive outcome for all.

CL02: 4:40-5 p.m. Suddenly Handicapped, How my Life Changed After a Serious Accident

Invited – Erin Sutherland

On August 2, 2013, I finished my classes for the day and got in my car to drive from Atlanta to Huntsville, AL, to meet some friends for dinner and a weekend of tennis. About halfway there, at the top of Lookout Mountain, I began to feel drowsy. I woke up a week later at Huntsville Hospital and my life has not been the same since. I spent another week in Huntsville Hospital, two weeks in a rehab hospital in Marietta, and three months bedridden at home and unable to bear weight on my shattered hip. It has been three years since the accident and I am still recovering and learning what it is like to have a disability that is not always obvious to others.

CL03: 5-5:30 p.m. This Is My Life: Building a Life and Career Within the Constraints of Disability

Invited – Christine Lindstrøm, Oslo and Akershus University College, Pilestredet 52, Oslo, Oslo NO-0130 Norway; christine.lindstrom@hioa.no

At the end of high school, I was diagnosed with rheumatoid arthritis. Since then, I have lived with severe chronic pain for about half the time, visited medical professionals on a monthly basis, and watched my joints slowly lose their flexibility. Despite these constraints, I have built a sustainable academic career, had a Fulbright fellowship, worked on five different continents and regularly travel the world. In this talk, I will share the life philosophy that enables me to achieve my dreams, utilizes my problem solving skills to work around constraints, and has led me to feel happy and positive. Ultimately, my journey is not primarily about learning to live with a disability—it is about learning to deal with life.

CL04: 5:30-5:40 p.m. Exploring How Students with Executive Function Disorders Perform in Physics

Contributed – Westley D. James, University of Central Florida, 12736 Lexington Summit Street, Orlando, FL 32828; westley.d.james@gmail.com

Benjamin Gallegos, Mathew Marino, Jacquelyn Chini, University of Central Florida

Research at the K-12 level repeatedly finds that students with disabilities are underserved by common educational models, leading to decreased performance on assessments of learning. Students with disabilities pursuing postsecondary degrees make up 2.5 million of the 23 million postsecondary population. However, little is known about these students' experiences in postsecondary STEM. In this study, we focus on students with disabilities identified with executive function needs, which cause differences in areas critical to physics learning, such as planning, working memory, attention and self-regulation. Executive function disorders (EFD) are common across several disabilities, such as attention deficit hyperactivity disorder, learning disabilities, and autism spectrum disorder. We explore the performance on popular physics concept tests for students with and without documented EFDs in both lecture-style and studio-style introductory physics courses at a very large research university, and address questions about how the models support students with EFDs.

TOP02: Solo PER

Location: CC - Breakout 8
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Women in Physics
Date: Monday, July 24
Time: 6–7:30 p.m.

Presider: Steve Maier

Are you the only professional active in PER within your department? Are there only one or two colleagues in close proximity you can talk "PER shop" with? The membership of Solo PER is larger than you may think, and more diverse than most suspect. Join us for this crackerbarrel to connect with other Solo PER professionals and learn what is being done to help our/your endeavors. As in the past, bring questions, ideas and professional concerns to share.

TOP03: Graduate Student Topical Discussion

Location: CC - Breakout 7
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Graduate Education in Physics
Date: Monday, July 24
Time: 6–7:30 p.m.

Presider: Daryl McPadden

This session is the primary opportunity for members of the PER graduate students and undergraduate communities to meet and discuss common issues.

Plenary Session

Location: CC - Event Center II
Date: Monday, July 24
Time: 7:30–8:30 p.m.

Presider: Gordon Ramsey

Julianne Pollard-Larkin

The Future of Image-Guided Radiotherapy will be MR-Guided, by Julianne M. Pollard-Larkin, *Assistant Professor of Medical Physics at the University of Texas, MD Anderson Cancer Center in Houston, TX*

Advances in image-guided radiotherapy (IGRT) have allowed for dose escalation and more precise radiation treatment delivery. Each decade brings new imaging technologies to help improve radiotherapy patient setup. Currently, the most frequently used method of 3D pre-treatment image verification is performed with cone-beam CT. However, more recent developments have provided radiotherapy with the ability to have on-board magnetic resonance (MR) imaging coupled to the Tele-radiotherapy unit. This latest tool for treating cancer is known as MR-guided radiotherapy (MR-gRT). Several varieties of these units have been designed and installed in centers across the globe. Their prevalence, history, advantages, and disadvantages will be discussed. Also, we will consider the possibilities of where MR-gRT might be heading in the near future.

TOP07: Improving Instruction Through Action Research

Location: CC - Breakout 4
Sponsor: AAPT
Date: Monday, July 24
Time: 6–7:30 p.m.

Presiders: Stephanie Slater, Tim Slater

How do you really know how well things are working in your class? This 90-minute topical discussion introduces faculty to standard practices in how to ethically conduct classroom action research with their students. Action research is a particular kind of data-based approach to identifying and finding evidence-based solutions for incrementally improving teaching and learning in your classroom. In today's era of increased accountability, including action research as an integral part of instructional planning and course design naturally generates artifacts and evidence for classroom effectiveness without unnecessarily robbing time from instruction. Participants and panelists will consider an overview of tools, surveys, and analysis techniques readily available and can be put to use right away.

Meet the New AJP Editor

Richard Price

Come to the Exhibit Hall (CC - Event Center I)

at the AAPT booth

Monday, July 24 at 3:30 p.m.

and

Tuesday, July 25 at 10 a.m.

PST1: Posters

Location: CC - Event Center I
Sponsor: AAPT
Date: Monday, July 24
Time: 8:30–10 p.m.

Poster presenters are asked to mount their posters by 8 a.m. The posters will remain available for viewing until 10 p.m. Persons with odd-numbered posters will present their posters from 8:30 p.m. to 9:15 p.m; those with even-numbered posters will present from 9:15 p.m. to 10 p.m.

Pre-college/Informal and Outreach

PST1A01: 8:30-9:15 p.m. Physics in the Park: Light and Colors Experiments for Children

Poster – Katemari D. Rosa, Federal University of Bahia, Av. Cardeal da Silva, 213 apt 37 - Federacao, Salvador, BA 40231-305 Brazil; katemari@gmail.com

Roberta Smania-Marques, State University of Paraiba

Julio Cesar Nascimento, Heloisa B. Almeida, Maria Ruthe Gomes, Federal University of Campina Grande

In this presentation, we share our experience developing and implementing outreach activities addressing colors and light phenomena for children ages 4 to 10 years old, in Campina Grande, a Northeastern state of Paraiba, Brazil. The experiments were divided by level of difficulty targeting two age groups, children 4 to 6 and 7 to 10. Activities were held both in classrooms for each age group, and in a central public park, open for children of all ages. Our presence in the park got the attention of many families who engaged with a variety of experiments; adults, youth, and children actively explored, made questions, and shared their explanatory models for the phenomena they experienced. Classroom activities were also very engaging but somewhat more structured, due to the physical space. Finally, not surprisingly, experiments that required a darker environment were found to harder to be performed in the park but easier in classrooms.

PST1A02: 9:15-10 p.m. The Chi Sci Scholars Program: Developing Supportive, Inclusive, Activities for Chemistry and Physics Majors*

Poster – Felicia Davenport, Chicago State University, 9501 S. King Drive - SCI 309, Chicago, IL 60628; frdavenport81@gmail.com

Fidel Amezcua, Nicolette Sanders, Kristy Mardis, Mel Sabella, Chicago State University

Ensuring that all students who want to pursue degrees and careers in science can do so is an important goal of a number of equity programs in college STEM throughout the United States. The CSU Chi Sci Scholars (CSS) program began in 2014 as a result of a grant from the National Science Foundation S-STEM Program and builds on the specific strengths and needs of our population on the southside of Chicago. The overarching goal of CSU's CSS Program are to increase the number of students receiving degrees in Chemistry and Physics by building science identity, creating a supportive cohort of peers, and providing financial support. Because of the population we serve at CSU, an implicit goal of the CSU S-STEM Program is increasing the number of underrepresented students entering the Physical Sciences. This poster presents some of the activities we engage in as part of the Chi Sci Scholars.

* Supported by the National Science Foundation (NSF DUE # 1356523), the Department of Education, and the CSU Center for STEM Education and Research.

PST1A03: 8:30-9:15 p.m. The MSU Science Theatre Upper Peninsula Trip

Poster – Patrick R Morgan, Michigan State University, 755 Science Rd., East Lansing, MI 48824; morgan@pa.msu.edu

Science Theatre is a nonprofit student outreach group at Michigan State University. Since 1992 they have coordinated with schools across the state of Michigan to visit and present in classrooms, at school assemblies, and for science nights or science fairs. In 2011, Science Theatre conducted the first annual Science Theatre Upper Peninsula Trip, or STUP Trip. This event, which happens during the MSU spring break, is when they visit as many of the Upper Peninsula schools as they are able to in a single week to perform full school assemblies. The STUP trip has grown in size over the years, with the 2017 event expected to visit over 40 schools in 20 different cities. This poster session will speak at length on how this event was started, how it has continued to expand and grow, and the important tips and lessons learned along the way.

PST1A04: 9:15-10 p.m. The NBI IKEA DIY Cloud Chamber

Poster – Ian Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark; bearden@nbi.dk

Axel Boisen, Marta Mrozowska, Niels Bohr Institute

As part of our outreach to secondary schools via our Ungdomslaboratoriet (Youth Lab), we have developed a DIY cloud chamber built almost exclusively of items available in the IKEA catalog. In fact, using these items, some isopropyl alcohol and dry ice, one can build a strikingly effective cloud chamber capable of showing atmospheric muons in roughly an hour. After this one time time investment, setup from storage container to viewing muons takes 20-30 minutes depending on the dexterity of the assembler. In this poster, we will show how to build the chamber as well as experiences using these chambers with secondary school students and teachers as well as using them in a laboratory exercise for upper level undergraduate students to view atmospheric muons as well as alpha and beta particles from a TIG thorium doped welding rod. The chamber will also be demonstrated in the poster session if there is room enough and it is possible to obtain dry ice.

PST1A06: 9:15-10 p.m. Bringing AP Physics to Underserved High School Populations

Poster – Mark D. Greenman, Boston University, 868 Humphrey Street, Swampscott, MA 01907; greenman@bu.edu

Boston University is in the second year of a pilot program, Project Accelerate, partnering with 11 high schools in Massachusetts and West Virginia to bring a College Board approved Advanced Placement® Physics Small Private Online Course to schools not offering this opportunity to students. Project Accelerate students (1) outperformed peer groups in traditional AP Physics classrooms on the College Board AP Physics exam, and (2) were more inclined to engage in additional Science, Technology, Engineering and Mathematics (STEM) programs than they were prior to participating in Project Accelerate. This poster will highlight the project research questions, methodology, implementation strategy, and pilot year outcomes. Project Accelerate offers a replicable solution to a significant problem of too few underserved high school students having access to high-quality physics education, resulting in these students being ill prepared to enter STEM careers and STEM programs in college.

PST1A07: 8:30-9:15 p.m. Composing Music to Illustrate Concepts in Fractals and Chaos*

Poster – Timothy L. McCaskey, Columbia College Chicago - Science and Mathematics Department, 600 S. Michigan Ave., Chicago, IL 60605-1996; tmccaskey@colum.edu

Luis Nasser, Columbia College Chicago

At Columbia College Chicago, we are interested in physics courses that encourage students to use artistic forms to illustrate their understanding of material. Our current "Physics for Filmmakers" course does this with a final film project. In that vein, and in the interest of adding new subject matter and artistic forms to our teaching arsenal, we have worked on a music composition project inspired by the introductory mathematics of fractals, chaos, and cellular automata. Our hope is that this work will act as a model for creative student projects in these subject areas. This poster will show how simple fractal patterns and computational exercises can be translated into choices of chord progression, rhythm, melody, and song structure. We will also use the poster to link to recordings of some of our compositions.

*This project is partially supported by a Faculty Development Grant from Columbia College Chicago.

PST1A08: 9:15-10 p.m. Engaging the Public Through an Interactive Astronomy Outreach Program

Poster – Kristen Thompson, Davidson College, Box 7133, Davidson, NC 28035; krthompson@davidson.edu

The growing technology sector of the U.S. economy in an increasingly complex world has made it more important than ever for students to gather information, think critically, and solve problems. These skills are often acquired through the study of STEM disciplines. In an effort to inspire students and the public in the Charlotte, NC, area to take an interest in STEM-related fields, the Physics Department at Davidson College has recently developed an interactive astronomy community engagement program. This program is composed of off-campus events that bring STEM programming to K-12 children, on-campus public star parties, and a day-long astronomy fair called Davidson Space Day. This presentation will illustrate the implementation of each of these components of our outreach program, present an evaluation of their success, and describe future goals and lessons learned thus far. This outreach program was made possible through funding from the NC Space Grant Consortium.

PST1A09: 8:30-9:15 p.m. Evaluating Physics and Astronomy Day: Measures for Determining Program Success

Poster – Kathleen A. Hinko, Michigan State University, 919 E. Shaw Ln., East Lansing, MI 48824-2320; hinko@msu.edu

Sonny Ly, Michigan State University

Getting children interested and excited about physics is often a main objective of university departmental outreach efforts. In an effort to expose children to the science of physics, Michigan State University has teamed up with a local science center, Impression 5, to host a Physics and Astronomy (PA) Day. During this annual event, guests have the chance to interact in person with physicists and take part in hands-on physics activities in a museum environment. In this work, we test several methodological approaches for embedding formative and summative assessment into the structure of PA Day. We focus on evaluating PA Day's success in delivering physics content that challenges guests to explore, ask questions, and formulate their own answers. We also evaluate PA Day's effectiveness in making guests excited about science. Our findings will be used to improve future PA Days and may be broadly applicable to similar one-time events.

PST1A10: 9:15-10 p.m. Brazilian Children's Spontaneous Reasoning About Light and Its Phenomena

Poster – Miriã Alves Alcântara, Instituto Federal da Bahia, Rua Emídio dos Santos, sem número, Barbalho, Salvador, BA 40.000-000 Brazil; luziammota@gmail.com

Luzia Matos Mota, Instituto Federal da Bahia

Isabelle Priscilla Carneiro Lima

Sérgio Luis Pita Santos, Josileide Ferreira Oliveira, Instituição Federal da Bahia

The goal of this work is to present the results of an exploratory research carried out with Brazilian children, ages 7 to 10 years old, with and without visual impairment, about their spontaneous reasoning on light and its phenomena. The methodology mobilized children to explore simple sensory experiences with emitting and non-emitting light objects. Then, children were asked to talk about their conceptions about the nature of light, its emitting sources, its characteristics, and its interaction with objects. The research was conducted individually and in focus groups. The results indicate that children, both with and without visual impairments, have spontaneous conceptions that allow them to explain everyday phenomena related to light. However, these conceptions, for the most part, differ from scientific explanations.

Lecture/Classroom

PST1B01: 8:30-9:15 p.m. How Do I Help Students Engage Productively ("buy in") in Active Learning Classrooms?

Poster – Stephanie Chasteen, University of Colorado Boulder, 247 Regal St., Louisville, CO 80027; stephanie.chasteen@colorado.edu

Andrew Boudreaux, Western Washington University

Jonathan Gaffney, Eastern Kentucky University

If you're incorporating active-learning strategies into your teaching, you may find that students don't automatically embrace this new learning approach. Students may just sit back and listen, waiting for their peers to answer. They may engage enthusiastically at first, but that exuberance wanes in the face of a busy semester. Students may even openly resist and complain (though this is somewhat rare). As instructors, we need to be mindful about how we structure the class structure and culture to make engagement feel safe and worthwhile. This poster will present results from a four-year project to document and disseminate what college STEM instructors do to generate student engagement, from the first day of class and beyond – and how these techniques align with research on student motivation and learning. Stop by and get ideas to use in the fall!*

*The full suite of materials can be found on PhysPort.org at https://www.physport.org/recommendations/Entry.cfm?ID=101163

PST1B02: 9:15-10 p.m. Identifying the Disciplinary Alignment of Student Ideas Using Textbook Analysis

Poster – Mashood KK, Michigan State University, Physics Education Research Lab, East Lansing, MI 48824-2320; mashoodkk123@gmail.com

Vashti Sawtelle, Charles Anderson, Emily Scott, Michigan State University

Rebecca Matz

Sonia Underwood Florida, International University

The emphasis on interdisciplinary thinking, both at the policy level and academia, has resulted in the development of new undergraduate science courses and curricula, but assessing interdisciplinary thinking remains challenging. An important consideration in this regard is to understand the extent to which students invoke different disciplines in their explanations about scientific phenomena. Literature review reveals that this process is often done by seeking opinion from content experts. We propose using student reflections and textbook analysis as two other possible modes for doing this. This poster discusses the process of textbook analysis, illustrating its advantages and limitations. Our data constitute student explanations of a set of everyday interdisciplinary phenomena such as the solidification of egg white on boiling. These phenomena were chosen such that they involve ideas from physics, chemistry and biology. Students were asked to explain them on the basis of what they have learned in different science courses.

PST1B03: 8:30-9:15 p.m. Two Stage Exams in the Modern Physics Classroom

Poster – Kristi D. Concannon, King's College, 133 North River Street, Wilkes Barre, PA 18711; kristiconcannon@kings.edu

Pedagogical innovation and active-learning methodologies are incorporated into introductory-level courses more frequently than in upper-level courses. For several years, I have been incorporating two-stage exams into my introductory courses with reasonable success. The two-stage exam reinforces to students the premise that learning can and should take place throughout the entire semester, not just in compartmentalized chunks; hence, exams can both be an opportunity for students to demonstrate what they have learned and an opportunity for students to continue to increase their understanding of the course material. Recently, I began implementing two-stage exams in my sophomore-level Modern Physics course. In this poster, I will compare the effectiveness of the two-stage exam in the introductory and sophomore-level courses.

PST1B04: 9:15-10 p.m. Using Art and Board Games to Understand Physical Concepts

Poster – Matt Olmstead, King's Colleg, Chemistry/Physics Department, King's College, 133 North River St., Wilkes Barre, PA 18711; matthewolmstead@kings.edu

I have implemented several lessons throughout our physics senior seminar class as an attempt to remind students of all they have learned. To do this, I wanted them to look at physics in a different way than they have in the past by using art and games. One of the games implemented involves all students drawing different ideas from physics while at the same time trying to determine what the others are drawing. For example, one round a student might be trying to draw general relativity (from a list including special relativity, gravity, Big Bang Theory, expansion of the universe, dark energy, and curvature of spacetime) while another students is drawing from a selection of physicists (including Einstein) and another student is drawing from ideas like Pauli-exclusion Principle, electron degeneracy pressure, etc. Distinguishing these similar concepts through student drawing requires focusing on aspects of physics from a different perspective.

PST1B05: 8:30-9:15 p.m. Ways to Decrease those DFW's in General Physics I

Poster – Karen A. Williams, East Central University, 1100 E. 14th St., Ada, OK 74820; kwilliams@ecok.edu

I will describe what I do in my General Physics I course that might help you retain the students and decrease your D's, F's, and W's in the course. At my institution we are on probation if we do not have less than a 25% average in all of our courses for student F's, W's, AW's. Some of these tips were given to me in different workshops. Some I tried and think they seem to help. Some things students told me helped. This is not a hardcore research poster with statistics as I am not sure I have data that far back to show change. This poster is a description of what might help you and your General Physics I (algebra based course) students since many faculty are penalized on annual evaluations when students drop or do poorly.

PST1B06: 9:15-10 p.m. A Pedagogical Trek Through a Tunnel in the Earth

Poster – Gerardo Giordano, King's College, 133 N River St., Wilkes-Barre, PA 18711; gerardogiordano@kings.edu

Thomas Concannon, King's College

A classic problem that introductory physics students are faced with is determining how long it takes an object to fall through a pole-to-pole deep bore hole through the Earth. In the standard setup for this problem, the Earths density is considered to be constant, its rotation is ignored and friction of all types is neglected. It provides a robust end-of-semester exercise that brings together Newton's Law of Gravitation, Newton's Shell Theorem, and simple harmonic motion while introducing the differential equations as a means of relating physics ideas. In this project, we expand on that idea by first adding a constant frictional term changing the homogeneous differential equation to a nonhomogeneous differential equation and suggesting an interesting way to explore the resulting differential equation. We further relax the constant density requirement and provide a novel way to introduce students to numerical analysis of the more complicated situation.

PST1B07: 8:30-9:15 p.m. Catholic University of Uruguay: Innovative Instructional Strategies in Mechanics

Poster – Wilson J. Gonzalez, Morehead State University, 405A Lappin Hall, Morehead, KY 40351; w.gonzalez-espada@moreheadstate.edu

Pablo Geille, Daniel Perciante, Departament of Natural Sciences, Catholic University of Uruguay, Montevideo

Marcos Sarasola Rosina Perez, Department of Education, Catholic University of Uruguay, Montevideo

The results of decades of research in physics teaching are starting to be integrated into even the most traditional classroom settings. This is the case of the Mechanics I class at Catholic University of Uruguay, the first course in the physics sequence for engineers. Strongly influenced by 20th century Western Europe, physics classes have been taught in a lecture style that is now slowly transitioning to more student-oriented classroom experiences with the integration of "concept-tests" and group assessments. The purpose of this session is to briefly describe how these innovative assessment strategies were implemented, to assess to what extent they were successful, and to suggest future avenues of inquiry.

PST1B08: 9:15-10 p.m. Deep Conceptual Thinking in High Needs Schools

Poster – Bradley F. Gearhart, 1982 Stony Point Rd., Grand Island, NY 14072; fizz6guy@yahoo.com

Dan MacIsaac, Buffalo State College

Kathleen Falconer, University of Cologne

Over the past six years, I have worked in two high schools within the Buffalo Public School District in Buffalo, NY, that have been state-identified as "Priority," "Persistently Low Achieving," and even less flatteringly "Failing." Despite these labels, I have witnessed, and documented, students engaging in deep levels of conceptual development that goes unrecognized in typical high stakes end of year state assessments. In this poster I provide primary evidence supporting my claim that, despite severe under performance on state issued Regents Exams, students within these schools are able to develop conceptual understanding that rivals those seen with inservice science teachers learning similar material for the first time and students in high-achieving high schools. It is my goal to help dispel the belief that failing schools are failing to engage students in the act of thinking and offer alternative suggestions for under-performance on these assessments.

PST1B09: 8:30-9:15 p.m. Developing Literacy in the 9th Grade Physics Classroom

Poster – Austin Hauser, Herron High School, 1221 Winter Hawk Ct., Greenwood, IN 46143; austinchauser@gmail.com

Rachelle Klinger, Herron High School

The development of literacy skills are often lost in the physics curriculum. At Herron High School, a public charter high school in Indianapolis, physics is taught as a first science course. Because of these two factors, we have gradually introduced literacy as an emphasis in our skills-based curriculum. We have developed materials, content, and instructional methods through close cooperation with our English and Social Studies departments. We will share our successes, challenges, and future goals for science literacy in physics, emphasizing examples of materials used in the curriculum.

PST1B10: 9:15-10 p.m. Magnetic Domain Theater: An Interactive Classroom Activity

Poster – Steven C. Sahyun, University of Wisconsin - Whitewater, 800 W. Main St., UW-Whitewater Physics Dept. Whitewater, WI 53190-1319; sahyuns@uww.edu

This poster will describe an easy-to-implement classroom activity used with pre-service elementary teachers in a studio-style Physics and Everyday Thinking (PET) course to enhance understanding about magnetic domains. In this activity, students are given a small sticky-note paper that is used as an analogy for magnetic poles and then arrange themselves to create a model of a nonmagnetic ferromagnetic material. Next, they rearrange themselves to create a magnetized object. This analogy also helps students understand why bar magnets are stronger at the ends rather than the center.

Upper Division and Graduate

PST1C01: 8:30-9:15 p.m. Investigating Transfer of Learning in an Upper-Level Quantum Mechanics Course*

Poster – Alexandru Maries, University of Cincinnati, 3405 Telford Street, Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

Transfer of learning from one context to another is considered a hallmark of expertise. Physics education research has often found that students have great difficulty transferring learning from one context to another. We examine upper-level and graduate students' facility with questions about the interference pattern in the double-slit experiment with single photons and polarizers in various orientations placed in front of one or both slits. Answering these questions correctly in the context of the double-slit experiment requires transferring learning about concepts from the context of a tutorial on Mach-Zehnder Interferometer (MZI) with single photons and polarizers in various paths of MZI. We discuss the extent to which students who worked through the MZI tutorial were able to transfer what they learned in that context to another context involving the double-slit experiment.

*Work supported by the National Science Foundation

PST1C02: 9:15-10 p.m. Learning Physical Biology via Modeling/Simulation: Undergraduate Course and Textbook*

Poster – Philip Nelson, University of Pennsylvania, Physics DRL / 209 South 33d St., Philadelphia, PA 19104; nelson@physics.upenn.edu

Undergraduate life-science curricula remain largely rooted in descriptive approaches, even though much current research involves quantitative modeling. Not only does our pedagogy not reflect current reality; it also reinforces the silos that prevent students from connecting disciplines. I'll describe a course that has attracted undergraduates in several science and engineering majors. Students acquire research skills that are often not addressed in traditional undergraduate courses, using a general-purpose platform like MATLAB or Python. The combination of experimental data, modeling, and physical reasoning used in this course represents an entirely new mode of "how to learn" for most of the students. These basic skills are presented in the context of case studies from cell biology, specifically control theory and its applications to synthetic biology. Documented outcomes include student reports of improved ability to gain research positions as undergraduates, and greater effectiveness in such positions, as well as students enrolling in more challenging later courses than they would otherwise have chosen.

*Work supported by NSF under grants EF–0928048 and DMR–0832802.

PST1C03: 8:30-9:15 p.m. Light, Imaging, Vision: An Interdisciplinary Undergraduate Course and New Textbook*

Poster – Philip Nelson, Univ Pennsylvania, Physics DRL / 209 South 33d St., Philadelphia, PA 19104; nelson@physics.upenn.edu

Students in physical and life science, and in engineering, need to know about the physics and biology of light. In the 21st century, it has become increasingly clear that the quantum nature of light is essential both for the latest imaging modalities and even to advance our knowledge of fundamental processes, such as photosynthesis and human vision. But many optics courses remain rooted in classical physics, with photons as an afterthought.\par I'll describe a new undergraduate course, for students in several science and engineering majors, that takes students from the rudiments of probability theory to modern methods like fluorescence imaging and Förster resonance energy transfer. After a digression into color vision, students then see how the Feynman principle explains the apparently wavelike phenomena associated to light, including applications like diffraction limit, subdiffraction imaging, total internal reflection and TIRF microscopy. Then we see how scientists documented the single-quantum sensitivity of the eye seven decades earlier than "ought" to have been possible, and finally close with the remarkable signaling cascade that delivers such outstanding performance. A new textbook, to be published in April 2017, allows others to replicate this course.

*Partially supported by the United States National Science Foundation under Grant PHY-1601894.

PST1C04: 9:15-10 p.m. Raising Physics to the Surface

Poster – Elizabeth Gire, Oregon State University, 367 Weniger Hall, Corvallis, Oregon 97333; giree@oregonstate.edu

Aaron Wangberg, Winona State University

Robyn Wangberg, St. Mary's University

The Raising Physics to the Surface project is to develop student-centered activities with carefully engineered tools to help students develop rich, geometric understandings of physics. The tools include 3D, transparent, dry-erasable surfaces that represent functions of two variables, corresponding contours maps and gradient maps, and inclinometers for measuring slopes on a surface. At this early stage of the project, we are prototyping activities and tools for topics in mechanics, E&M and thermal physics courses. We present some of this preliminary work, including examples of activities and tools that represent physical systems that are relevant to physics instruction.

PST1C05: 8:30-9:15 p.m. Visualizing the Electromagnetic Field Tensor in Spacetime

Poster – Roberto B. Salgado, U Wisconsin La Crosse, 1725 State St., La Crosse, WI 54601; rsalgado@uwlax.edu

Tobias A. Nelson, U Wisconsin La Crosse

We describe how the electromagnetic field tensor can be visualized using a pair of bivectors in spacetime. Using a geometric construction due to Baylis, we obtain the transformation formulas for the electric and magnetic fields in special relativity. We apply this idea to some simple configurations of the electromagnetic field, as viewed in different frames of reference.

PST1C06: 9:15-10 p.m. Web Apps for Wave Functions, Spins, and Entanglement

Poster – Daniel V. Schroeder, Weber State University, 2508 University Circle, Ogden, UT 84408-2508; dschroeder@weber.edu

As quantum pedagogy forges in new directions and Java applets fade into history, there is a growing need for modern web apps--written in HTML5 and JavaScript for use on both personal computers and mobile devices--to help students perform numerical calculations and visualize quantum phenomena. This poster will highlight new apps for building wave functions as superpositions of basis states; animating wave functions in one and two dimensions with color hues to represent phase; simulating two-particle interactions to show entangled wave functions; and linking simulated Stern-Gerlach devices to study incompatibility and interference in spin systems.

http://physics.weber.edu/schroeder/software/

PST1C07: 8:30-9:15 p.m. An Intermediate Course in Scientific Computing

Poster – Mark E. Rupright, Birmingham-Southern College, 900 Arkadelpha Road, Birmingham, AL 35254-0001; mruprigh@bsc.edu

I reflect on the first run of an undergraduate course in scientific computing for physics, mathematics, engineering, and chemistry majors. The course is designed to fit into the gap between introductory "how to use Matlab" and advanced numerical analysis courses, and provides necessary tools for using computing in advanced science and mathematics courses, as well as advanced undergraduate research. I will share experience and solicit ideas and feedback on the course design and implementation.

PST1C08: 9:15-10 p.m. Core Graduate Courses: A Missed Learning Opportunity?*

Poster – Alexandru Maries, 3405 Telford Street, Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

An important goal of graduate physics core courses is to help students develop expertise in problem solving and improve their reasoning and meta-cognitive skills. We explore the conceptual difficulties of physics graduate students by administering conceptual problems on topics covered in undergraduate physics courses before and after instruction in related first year core graduate courses. Here, we focus on physics graduate students' difficulties manifested by their performance on two qualitative problems involving diagrammatic representation of vector fields. Some graduate students had great difficulty in recognizing whether the diagrams of the vector fields had divergence and/or curl but they had no difficulty computing the divergence and curl of the vector fields mathematically. We also conducted individual discussions with various faculty members who regularly teach first year graduate physics core courses about the goals of these courses and the performance of graduate students on the conceptual problems after related instruction in core courses.

*Work supported by the National Science Foundation

PST1C09: 8:30-9:15 p.m. Damped Oscillations of a Free Piston in a Gas-Filled Cylinder

Poster – Carl E. Mungan, United States Naval Academy, Physics Mailstop 9c, Annapolis, MD 21401-3217; mungan@usna.edu

If a cylinder is capped off by a sliding piston, we have a situation analogous to a mass on a spring. With suitable idealizations (hanging vertically in vacuum from a Hookean spring attached to a rigid support), the mass on the spring is undamped and it will oscillate forever if initially displaced from equilibrium. With other suitable idealizations (the piston has no friction with the cylinder, the gas is ideal with no viscosity or turbulence, there is vacuum on the other side of the piston, the piston and cylinder have zero thermal conductivity and heat capacity) will the piston similarly oscillate forever if initially displaced? No! Unlike the solid bonds inside a spring, the gas molecules are mobile and so the analog is not exact. In fact, the motion of a piston in a gas-filled cylinder is always damped.[1] However, the damping is weak and so the frequency of oscillation in a Ruchardt experiment closely approximates the undamped frequency.

1. C.E. Mungan, "Damped oscillations of a frictionless piston in an adiabatic cylinder enclosing an ideal gas," European Journal of Physics, Vol. 38 (2017).

PST1C10: 9:15-10 p.m. Developing an Interactive Tutorial on a Quantum Eraser

Poster – Emily M. Marshman, University of Pittsburgh, 209 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We developed a quantum interactive learning tutorial (QuILT) on a quantum eraser for students in upper-level quantum mechanics. The QuILT exposes students to contemporary topics in quantum mechanics and uses a guided approach to learning. It adapts existing visualization tools to help students build physical intuition about quantum phenomena and strives to help them develop the ability to apply quantum principles in physical situations. The quantum eraser apparatus in the gedanken (thought) experiments and simulations that students learn from in the QuILT uses a Mach-Zehnder Interferometer with single photons. We also discuss findings from in-class evaluations. We thank the National Science Foundation for Support.

PST1C11: 8:30-9:15 p.m. Development and Validation of a Conceptual Survey on the Formalism and Postulates of Quantum Mechanics

Poster – Emily M. Marshman, University of Pittsburgh, 209 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We discuss the development and validation of a conceptual survey about the formalism and postulates of quantum mechanics. The survey can be used to evaluate the effectiveness of various types of instructional approaches and pedagogies to help students learn quantum mechanics concepts tested in the survey such as properties of the states of a quantum system and their time-development, issues related to the measurement of observables, expectation values and their time dependence, Dirac notation and spin angular momentum. After the development and validation, the survey was administered to more than 350 students at six institutions. We find that undergraduate and graduate students have many common difficulties with these concepts and that research-based instructional strategies can significantly reduce these difficulties. We thank the National Science Foundation for support.

PST1C12: 9:15-10 p.m. Exploring Mathematical Sense-making in Quantum Mechanics

Poster – Erin Ronayne Sohr, University of Maryland College Park, Toll Building, College Park, MD 20740; erinsohr@gmail.com

Ayush Gupta, University of Maryland College Park

Coordinating between mathematical formalism and the referent physical system is widely accepted as important in physics problem-solving, with mathematical sense-making being a type of such coordination. We use the term mathematical sense-making to mean coherence-seeking between the heart of the mathematics and the physical system, such as seeing the kinematics velocity equation as "saying" the final velocity is equal to the initial velocity plus the change in the initial velocity. Accounts of how mathematical sense-making can be useful in problem-solving have largely been limited to classical physics. We aim to extend the notion of mathematical sense-making to quantum mechanics. We draw on clinical interviews with physics graduate students to analyze how students with several semesters of experience seek coherence between a physical system and its associated mathematical formalism in quantum mechanics. We will present our preliminary analysis.

Technologies

PST1D01: 8:30-9:15 p.m. iPad Video Projects in Introductory Physics Courses

Poster – Dan MacIsaac, SUNY Buffalo State College, 1300 Elmwood Ave,m Buffalo, NY 14222; danmacisaac@mac.com

Andrew Roberts, Sherburne-Earlville HS

David Abbott Roberts, Brad Gearhart Kathleen Falconer, SUNY Buffalo State College

We present and discuss the use of short for-credit iPad video projects in introductory physics classes for freshman non-majors and HS physics students. We present guidelines for instructors and students, common video tools and techniques, classroom management strategies, grading and lessons learned.

PST1D02: 9:15-10 p.m. Peer Instruction Through Video Homework Assignments

Poster – Artur Tsobanjan, King's College, Wilkes-Barre, 133 North River Street, Wilkes-Barre, PA 18711; arturtsobanjan@kings.edu

Physics instructors are always looking for ways to actively engage students in and out of the classroom, as well as to provide them with opportunities to instruct each other. Assigning video presentations of solutions to problems as homework has helped me accomplish both goals in several college-level courses I have taught. This poster summarizes the implementation, results, and student responses to my use of this instructional tool. It also provides suggestions for other instructors wishing to use the same technique in their classroom.

PST1D03: 8:30-9:15 p.m. Position and Velocity vs. Time Graphs with Arduino

Poster – Nathan A. Quarderer, Northeast Iowa Community College, 1625 Hwy 150, Calmar, IA 52132; quarderern@nicc.edu

In response to recent pushes for integration of STEM (technology, engineering, and mathematics) into the science curriculum, coupled with growing momentum behind the 'maker' movement, I have been inspired to re-think the way I approach activities in my introductory physics classroom. The widely available Arduino microcontroller provides an inexpensive means of infusing traditional physics lessons with a hint of STEM, giving students the opportunity to build their own data acquisition devices. I will demonstrate one example of how I'm using these ideas with my classes, during a unit on one-dimensional motion. Students build and program a motion detector, and then use it to obtain information about how their position, and velocities change with time. These data are exported from Arduino, and represented graphically using Excel. While this may take longer than traditional techniques reliant on the use of commercially available equipment, the time spent data wrangling has proven to be beneficial.

PST1D04: 9:15-10 p.m. Using Two Simulation Tools to Teach Concepts in Introductory Astronomy

Poster – Pamela A. Maher, University of Nevada, Las Vegas, 718 Lacy Lane, Las Vegas, NV 89107; maherp@unlv.nevada.edu

Janelle M. Bailey, Temple University

This poster describes design-based research examining affordances and constraints of two simulation tools for use in introductory college astronomy courses. We seek to understand the variety of experiences students have using two tools: a virtual reality headset and a motion sensor device used to manipulate a lunar flyby. The sample size of this mixed methods study is N = 65 participants drawn from two semesters of classes at a two year college. Each participant engaged in a treatment manipulating a lunar flyby using a virtual reality headset in the virtual reality laboratory and then manipulating a lunar flyby using a motion sensor device in the college planetarium. Data collected in post-treatment questionnaires using Likert-type scales and mini-interviews in focus group settings is are currently being analyzed for salient themes using horizontalization informed by a theoretical framework of phenomenography to identify the variety of participant experiences.

PST1D05: 8:30-9:15 p.m. We Want YOU for PICUP*

Poster – Larry Engelhardt, Francis Marion University, 4822 E. Palmetto St., Florence, SC 29506; lengelhardt@fmarion.edu

Marie Lopez del Puerto, University of St. Thomas

Marcos Caballero, Michigan State University

Norman Chonacky, Yale University

Robert Hilborn, American Association of Physics Teachers

There are exciting opportunities for you available from "PICUP" (the "Partnership for Integration of Computation into Undergraduate Physics"). These opportunities include week-long workshops during the summer, single-day workshops at national AAPT and APS meetings, and editable curricular materials that can be downloaded from the PICUP Collection of the ComPADRE Digital Library: www.compadre.org/PICUP. Do you already integrates computation into your courses? If so, you should submit your materials for publication in the PICUP Collection, which gives you the opportunity to both (1) contribute to the broader physics community, and (2) get some peer-reviewed publications in the process!

*This project is funded by the National Science Foundation under DUE IUSE grants 1524128, 1524493, 1524963, 1525062, and 1525525. One more author: Kelly Roos, Bradley University

PST1D06: 9:15-10 p.m. A Workshop on Programming Sensors with Python

Poster – Glenda Denicolo, Suffolk County Community College, 91 Ontario St., Port Jefferson Station, NY 11776; glenda.denicolo@gmail.com

Michael A Zingale, Stony Brook University

During fall 2016 we implemented a pilot workshop at SCCC to train students on programming sensors using the computer language Python. Our goal was to focus on the graphical interpretation of the data collected by the sensors, therefore we chose Python (in Jupyter notebooks) because it offers advantages for visualization of data over other languages. The sensors were controlled by an Arduino, which interpreted the code in Python via a StandardFirmata protocol. The workshop was free, and open to students of all disciplines during four weeks during common hour. The 20 participants learned basic aspect of Python, Arduino, and circuitry. Students worked with sensor for light, sound, pulse, and soil moisture. We plan to offer it again fall 2017, add more sensors to the list, expand the workshop schedule, and include group projects.

PST1D08: 9:15-10 p.m. Customizing Computer Coaches to Align with My Preferred Pedagogy*

Poster – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099; pawla@uwplatt.edu

Since 2010 I have been struggling to get my students to use a structured approach to problem solving in mechanics: the "System, Interactions, Model" or "S.I.M." strategy. One of the greatest difficulties is the fact that standard web-based homework systems are usually too limited to teach or even reinforce structured problem solving behavior among students. When I learned about the "C3PO" customizable computer coach software system developed in 2014 by the University of Minnesota Physics Education Research group*, I felt I had finally found a system that could be adapted to teach the SIM approach. Beginning in fall 2016 I have deployed 5 tailored computer coaches as part of the homework in my introductory mechanics courses. I will present what I learned from the process of customizing these coaches and how they have affected the performance of my students.

*K. Heller, E. Frodermann, L. Hsu, Q. Ryan and B. Aryal, 2014 AAPT Summer Meeting; http://groups.physics.umn.edu/physed/prototypes.html.

PST1D09: 8:30-9:15 p.m. Cycling Through R&D: Testing Usability of Next Generation Computer Coaches

Poster – Emily M. Smith, University of Minnesota, 116 Church St. SE, Minneapolis, MN 55455; smithem@umn.edu

Evan Frodermann, Missouri State University

Ken Heller, Leon Hsu, Jie Yang, University of Minnesota

Problem solving is an important component of introductory physics. Using the internet to provide on-demand coaching for students taking this challenging course seems obvious, however, the development of such problem solving coaches is complicated. The C3PO project uses the well-established Deming R&D process to iteratively develop coaches in stages moving continuously between laboratory prototype and in situ testing. This poster focuses on in situ usability testing at two large research universities. Such testing is also in progress at a two-year college and a state university. This work was partially supported by NSF DUE-1504649 and a University of Minnesota Learning Innovations Grant.

PST1D10: 9:15-10 p.m. HTML5 Simulations and a Virtual Lab on Radioactive Decay for Introductory Courses

Poster – Steven C. Sahyun, University of Wisconsin - Whitewater, 800 W. Main St., Whitewater, WI 53190-1319; sahyuns@uww.edu

This poster describes four HTML5 simulations and one virtual laboratory that have been created and made accessible on the Internet. Two of the simulations are Newton's second law and Centripetal Force, and are regularly used to enhance instruction in a Physics and Everyday Thinking (PET) course. Two additional simulations* provide examples of relativity: a Minkowski space-time diagram that is used in an introductory physics course and a simulation on Lorentz contraction and time dilation that is used in a conceptual survey course called From Einstein to Star Trek. In addition, this poster will describe a virtual laboratory using streaming video and acquired decay data from several neutron-activated materials as well as video examples of other radioactive materials.

*These simulations are available at http://sahyun.net/html5

PST1D12: 9:15-10 p.m. OpenStax Tutor for College Physics

Poster – Chadwick H. Young, Nicholls State University, 201 E. 6th St., Thibodaux, LA 70301; chad.young@nicholls.edu

OpenStax, a provider of open-source college textbooks, will soon roll out its Tutor system. OpenStax Tutor is an online education software designed to provide good pedagogical practices and help students to achieve mastery. I present my experience from piloting the software in a 100-student, algebra-based college physics course for life-science students.

Physics Education Research

PST1E01: 8:30-9:15 p.m. Development and Growth of PhysPort

Poster – Sarah B. McKagan, American Association of Physics Teachers 124 28th Ave. Seattle, WA 98122; sam.mckagan@gmail.com

Eleanor C. Sayre, Kansas State University

Adrian M. Madsen, American Association of Physics Teachers

Lyle Barbato

PhysPort.org is a website that supports physics faculty in using research-based teaching and assessment in their classrooms. PhysPort offers multiple resources including overviews of over 50 research-based teaching methods and over 80 research-based assessments, along with the Virtual New Faculty Workshop and the Periscope collection of video-based TA training and faculty professional development materials. It also includes Expert Recommendations with specific guidance on implementing research-based teaching and assessment, and the Data Explorer which provides instant analysis and visualization of research-based assessment results. PhysPort has been supported through multiple NSF grants since 2009. It has grown steadily since its launch in 2011 (when it was called the PER User's Guide), both in terms of the number and types of resources it offers, and the number of users. In this talk we will present an overview of the growth of resources available on PhysPort, along with data on the usage of the site.

PST1E02: 9:15-10 p.m. Eight Key Findings for Successful Propagation of Educational Innovations*

Poster – Raina M. Khatri, Western Michigan University, 1903 W. Michigan Ave., Kalamazoo, MI 49008 raina.m.khatri@gmail.com

Charles Henderson, Western Michigan University

Science education researchers have developed many new instructional strategies and materials, and these can be shown to improve student learning and retention. However, very few of them become widely used beyond their home institution. To address this, we have studied typical education development projects and successfully propagated projects through case studies and interviews with the project teams – through comparison, we have identified strengths behind the propagation activities of successful projects, resulting in eight key findings about how education developers currently think about propagation, and what they can do to emulate successful projects to increase the impact of their work.

*This work is supported by NSF grant no. 1122446.

PST1E03: 8:30-9:25 p.m. Exploring Student Communities in Group Exam Settings

Poster – Steven F. Wolf, East Carolina University, Department of Physics, Greenville, NC 27858-4353; wolfs15@ecu.edu

Timothy Sault, East Carolina University Depertment of Physics

Cody Blakeney, Hunter G Close, Texas State University

Collaboration is an integral part of science, and as our classrooms become more collaborative, so to can our assessments. Group exam data gives us a new kind of data about how our students relate to each other. Network analysis provides many tools for describing, visualizing, and analyzing student networks. In particular, we are interested in probing many different aspects of these communities. For example, how does network position relate to content knowledge? And can we track how ideas flow through a class?

PST1E04: 9:15-10 p.m. Exploring Students' Disciplinary Reasoning About Sneezing

Poster – Justin E. Gambrell, Michigan State University, 567 Wilson Rd., East Lasning, MI 48824; gambre11@msu.edu*

Vashti Sawtelle, Emily Scott, Michigan State University

Sonia Underwood, Florida International University

On the road to knowing whether college students understand how the sciences are related, we must first understand how to characterize their knowledge based on the discipline. We interviewed students with a background of at least one introductory chemistry, biology, and physics class and asked them to reason about the phenomenon of sneezing as a transfer of disease. Using these interviews, we explored whether the concepts and ideas students were invoking were concepts found in the introductory science textbooks. In this presentation we discuss our work linking students' scientific vocabulary with textbooks (both physical and electronic), and which ideas students commonly invoke. We use this data to make a claim about whether the knowledge students draw upon is related to the information in these introductory science textbooks. Our work shows that the concepts that students used in explaining sneezing were rarely found in the introductory chemistry or introductory physics textbooks.

*Sponsored by Vashti Sawtelle

PST1E05: 8:30-9:15p.m. Exploring the Underlying Factors in Faculty – Learning Assistant Partnerships*

Poster – Fidel Amezcua, Chicago State University, 9501 S. King Drive - SCI 309, Chicago State, University Chicago, IL 60628; famezcua@csu.edu

Felicia Davenport, Mel S Sabella, Andrea Van Duzor, Chicago State University

An effective Learning Assistant (LA) Program can provide a variety of benefits for both LAs and faculty. A key component of the LA Program is the Faculty led weekly preparation sessions. Our previous work suggests that different types of partnerships can arise during these meetings. We leverage a combination of qualitative and quantitative data to better understand what types of skills faculty value and how this affects the formation of these partnerships. These qualitative and quantitative methods are used to gain insight into how these partnerships develop. Measures include LA and faculty reflections, videos of weekly preparation sessions, and interviews.

*Supported by the National Science Foundation (DUE#1524829), the Department of Education, and the CSU Center for STEM Education and Research.

PST1E06: 9:15-10 p.m. Factors Facilitating Children's Engagement with Science Activities on Web-based Simulations about Magnetic Field*

Poster – Youngseok Jhun, Seoul National University of Education, 96, Seochojungang-ro, Seocho-gu, Seoul, 137-742; youngseok.jhun@gmail.com

Sooah Lee, Seoul National University of Education

This study is to design an evaluating rubric for web-based science simulations in terms of contents, strategies and simulation formats to facilitate children's engagement with science activities. We administered the rubric to 14 web-based simulations about magnets and magnetic field. Eight elementary teachers participated in the evaluation and described specific characteristics of each simulation according to the criteria. Based on the evaluation, we divided the simulations into two groups, excellent vs. normal groups. We analyzed strong points from the simulations in excellent group and weak points from the simulations in normal group according to the contents, learning strategies, screen format, and technical features. Implications for ways of how to use web-based science simulations effectively for children to engage with science inquiry activities in elementary level were discussed.

*This work was supported by Institute for Information & communications Technology Promotion(IITP) grant funded by the Korea government(MSIP) (No. R0115-16-1011, Physics-based solutions for science experiments in e-Book)

PST1E07: 8:30-9:15 p.m. Faculty Online Learning Communities: What Role Does Community Play?

Poster – Alexandra Lau, University of Colorado Boulder, 850 20th St, Apt 501, Boulder, CO 80302; alau693@gmail.com

Melissa Dancy, University of Colorado Boulder

Charles Henderson, Western Michigan University

In 2015 we ran our first Faculty Online Learning Community (FOLC) to support new faculty in the year following their attendance at the Physics and Astronomy New Faculty Workshop (NFW). FOLC cohorts meet biweekly via a video conferencing program and connect between meetings using an asynchronous communication platform. Previous work shows that participants of the NFW face challenges in implementing techniques learned at the workshop when they return to their home institutions [1]. Our FOLCs are designed to create a support network among members as they navigate these challenges. This poster will describe our analysis of the role of community in our FOLCs. Data is drawn from post-interviews of members from our four completed cohorts. Emergent themes from our analysis will be highlighted.

1. C. Henderson, M. Dancy, and M. Niewiadomska-Bugaj, Phys. Rev. ST Phys. Educ. Res. 8, 020104 (2012).

PST1E10: 9:15-10 p.m. High School Students' Physics Course Credit Attainment in Texas

Poster – Liang Zeng, The University of Texas-Rio Grande Valley, 1201 W. University Drive, Edinburg, TX 78539; liang.zeng@utrgv.edu

G. Herold Poelzer, The University of Texas-Rio Grande Valley

Using Texas Public Education Information Management System data between 1997 and 2009, this study describes the trends in course credit attainment (CCA) and course registration of high school students in Physics, AP Physics B, AP Physics C, and IB Physics courses in Texas.

Different from other studies, it focuses on CCA trends across ethnicities, gender, and those in or not in gifted programs. Furthermore, it investigates the gaps of CCA between Hispanic and White students within gifted or not in gifted programs and gender. In addition, the trends in course registration are investigated with respect to the proportion of male and female students across ethnicities. Significant trends in gap dynamics between Hispanic and white students suggest problems with Hispanic minority students in physics education in high schools in Texas, especially since the Hispanic student population is steadily increasing and already surpasses the white student population.

PST1E11: 8:30-9:15 p.m. How Can We Shape Our Resources-Oriented Research to be Most Useful for University Physics Instructors?*

Poster – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave W Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu

Lisa M. Goodhew, Paula R L Heron, University of Washington

Rachel E. Scherr, Seattle Pacific University

Misconceptions research—including research that identifies common, incorrect student ideas—has had a substantive impact on university physics instruction. For example, misconceptions research has provided faculty with knowledge and tools to elicit, confront, and resolve particular misconceptions. This project takes up a different lens – a resources-oriented lens—which assumes that student ideas can be framed as the beginnings of physics understandings, and that instruction can build from these understandings toward instructional targets. In this data-intensive poster, we will share examples of resources that we have identified in students' written responses to conceptual questions about forces. Our aim is to speak with physics instructors from a variety of institutions who may use the results of our research (e.g., the resources we identify) to inform their instruction, so that we can shape the substance and form of our future work to meet the needs and interest of our audience.

*This work was supported in part by NSF DUE 1608510.

PST1E12: 9:15-10 p.m. How Seriously Do Students Take Assessment Tests?

Poster – Michael P. Orleski, Misericordia University, 301 Lake St., Dallas, PA 18612; morleski@gmail.com

Physics Education Research (PER) often makes use of standardized tests such as the Force Concept Inventory. Those in PER seem to acknowledge that students do not take assessment tests seriously. The usual recommendation is to give some form of credit for taking the tests. To investigate the question of level of seriousness and effort in assessment tests a short survey was created. The survey was given to all students taking Physics Department courses at Misericordia University in the spring 2016 semester and the 2016-17 academic year. The results of the survey are presented in this poster.

PST1E13: 8:30-9:15 p.m. How Students Use Far Analogies to Understand New Physics Concepts

Poster – AJ Richards, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; aj.richards@tcnj.edu

David Brookes, Florida International University

Eugenia Etkina, Rutgers University

We have documented a small group of preservice physics teachers learning about how a solar cell functions and examined how they use analogical reasoning. In particular, we note how they devise far analogies (analogies to non-physics, everyday-life phenomena, described by Dunbar [1995]* as "long-distance analogies") to "wrap up" a discussion of a certain topic and to demonstrate understanding or attempt to explain the situation to a groupmate who remains uncertain. These far analogies represent important "mileposts" in the conversation, as we observe that students almost always employ them only after they feel confident in their understanding of the concept. We will present several notable examples and discuss implications of their use in student reasoning about new physics ideas.

*K. Dunbar. "How scientists really reason: Scientific reasoning in real-world laboratories." The nature of insight, 18 (1995): 365-395.

PST1E14: 9:15-10 p.m. Identifying High Leverage Practices in Learning Assistant Implementations

Poster – Daniel Caravez, CSU Chico, 48 Tara Terrace Apt. 1, Chico, CA 95929; dcaravez2@gmail.com

Jayson Nissen, Nancy Caravez, Angelica De La Torre, Ben Van Dusen. CSU Chico

The Learning Assistant (LA) model is designed to provide a platform to support a wide variety of classroom specific transformations. This investigation examines the impacts of LAs across implementations to identify discipline-specific high-leverage LA practices. To do this, we will leverage the statistical power of the Learning About Student Supported Outcomes (LASSO) platform to create Hierarchical Linear Models that include student concept inventory data, student demographics, and course level data from science classes across the country. Implications for the implementation of LA programs will be discussed.

PST1E15: 8:30-9:15 p.m. Impact of Situational Factors on Student Attitudes in Introductory Physics

Poster – Brian Zamarripa Roman, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816; b.zamarripa@knights.ucf.edu

Jacquelyn J. Chini, University of Central Florida

Attitudinal assessments in physics have been developed to probe what students believe about physics and learning physics. Both pre-instruction assessment scores and the change in those scores as a result of instruction (gains) have been shown to be affected by factors such as student gender, previous experience with physics, and type of math required in the physics course. In this investigation, we examine the Colorado Learning Attitudes about Science Survey to determine the effect of situational factors on assessment scores and gains. The effects of situational factors such as income and parent college experience were tested through statistical analysis of scores gathered over five semesters of introductory physics courses.

PST1E16: 9:15-10 p.m. Improved Epistemology Through Discussions on Characteristics of Scientists

Poster – Bradley K. McCoy, Azusa Pacific University, 901 E Alosta Ave., Azusa, CA 91702-7000; bmccoy@apu.edu

This quasi-experimental study examines changes in students' epistemologies during a first university physics course using the EBAPS instrument. The course includes brief daily discussions of characteristics of scientists. We find that in courses including these daily discussions, students' epistemologies do not undergo the degradation that is typical in a first physics course. This low-impact intervention may increase retention by decreasing the number of individual students with large negative changes in epistemology.

PST1E17: 8:30-9:15 p.m. Improving Students' Understanding of Lock-in Amplifiers

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; stdevore@mail.wvu.edu

Alexandre Gauthier, Jeremy Levy, Chandralekha Singh, University of Pittsburgh

A lock-in amplifier is a versatile instrument frequently used in physics research. However, many students struggle with the basic operating principles of a lock-in amplifier which can lead to a variety of difficulties. To improve students' understanding, we have developed and evaluated a research-based tutorial which utilizes a computer simulation of a lock-in amplifier. The tutorial is based on a field-tested approach in which students realize their difficulties after predicting the outcome of simulated experiments involving a lock-in amplifier and check their predictions using the simulated lock-in amplifier. Then, the tutorial guides and helps students develop a coherent understanding of the basics of a lock-in amplifier. The tutorial development involved interviews with physics faculty members and graduate students and iteration of many versions of the tutorial with professors and graduate students. The student difficulties and the development and assessment of the research-based tutorial are discussed. Supported by the NSF.

PST1E18: 9:15-10 p.m. Improving Texas School Comparison Groups via Modern Clustering Techniques

Poster – Matthew Guthrie, The University of Texas at Austin, 2515 Speedway, C1600, Department of Physics, RLM 14.312 Austin, TX 78712-1192; mwguthrie@physics.utexas.edu

Michael Marder, The University of Texas at Austin

What are the primary factors that make one school similar to another? The Texas Education Agency utilizes the Euclidean distance between a small number of factors (e.g. total number of students and the percentage of students who qualify for free/reduced price lunch) to sort schools into comparison groups. While this is helpful in limited contexts, the factors currently used for this sorting are not the most effective set for that application and the sorting method is not well justified. Modern clustering techniques (such as network community detection) can help researchers identify the factors most strongly affecting outcomes, and these factors can then be used to define more meaningful comparison groups. This definition will ultimately allow for appropriate metrics of school performance. This poster will detail the application of community detection in the Texas high school system and the use of these communities for the identification of exemplary schools.

PST1E19: 8:30-9:15 p.m. Inequitable Physics: Developing Curricula to Emphasize a Need for Change

Poster – Sierra R. Decker, Seattle Pacific University, 3018 4th Ave W, Seattle, WA 98119; deckers@spu.edu

Abigail R. Daane, Seattle Pacific University

In an introductory university physics course, we taught a unit about racial inequity, explicitly highlighting the glaring underrepresentation of people of color and women in the physics community. The weeklong equity unit emphasizes that while physics is often described as objective and uninfluenced by racial and cultural differences, in reality, both current and future physicists are affected by their personal experiences. The development and teaching of physics is impacted by the people who participate (or do not participate) in the community, yet this issue has been left out of most physics curricula. We provide a description of an equity unit appropriate for introductory university physics that aims to increase awareness of racial inequity and empower students to become agents of change.

PST1E20: 9:15-10 p.m. Inquiry-based Learning in the Physics Classroom

Poster – Yu Gu, Juniata College, 1700 Moore Street, Huntingdon, PA 16652-2119; gu@juniata.edu

Inquiry-based learning has been known to narrow the learning gap between students with different levels of background in the scientific fields. Physics, in particular, is challenging because it requires both mastery of concepts and mathematical skills and can benefit greatly from inquiry-based learning. We examine inquiry-based learning in algebra and physics-based introductory physics courses, and present the "mystery tube" as a useful tool for first-year student's learning of Newtonian mechanics.

PST1E21: 8:30-9:15 p.m. Instructor Approaches to Teaching Computation in Collaborative Physics Problem Solving

Poster – Alanna S. Pawlak, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824-1046; pawlakal@msu.edu

Paul W. Irving, Marcos D. Caballero, Michigan State University

An increasing emphasis is being placed on incorporating "authentic practices" into introductory physics courses, for example, through the inclusion of computational problems. Such problems can allow students to engage with the programming practices and numerical problem solving methods used by physicists. We conducted interviews with the instructors in a problem-based introductory mechanics course where students solved several computational problems. In these problems, students were provided minimally working programs in VPython that they had to modify in order to correctly model the physics of the situation in question. The instructors in this course come from a range of backgrounds, and include undergraduate learning assistants, graduate teaching assistants, and faculty from several subdisciplines of physics. We present preliminary analysis of these interviews suggesting that there are distinct ways that instructors may approach teaching computational problems in this environment.

PST1E22: 9:15-10 p.m. Investigating and Addressing Student Difficulties with Fundamental Concepts in Degenerate Perturbation Theory

Poster –Christof K. Keebaugh, University of Pittsburgh, 295 Hillcrest Circle, Pittsburgh, PA 15260-3583; ckk10@pitt.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with degenerate perturbation theory (DPT) carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We find that students share many common difficulties related to this topic. We used the difficulties found via research as resources to develop and evaluate a Quantum Interactive Learning Tutorial (QuILT) which strives to help students develop a functional understanding of DPT. We discuss the development of the DPT QuILT and its preliminary evaluation in the undergraduate and graduate courses. We thank the National Science Foundation for support.

PST1E23: 8:30-9:15 p.m. Investigating and Improving Introductory Physics Students' Understanding of Coulomb's Law and Gauss's Law

Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Jing Li, University of Pittsburgh

We discuss an investigation of the difficulties that students in university introductory physics courses have with Coulomb's law and Gauss's law and how that research was used as a guide in the development and evaluation of a research-validated tutorials on these topics to help students learn these concepts better. The tutorials use a guided inquiry-based approach to learning and involved an iterative process of development and evaluation. We also compare student performance in classes in which students worked on the tutorials with other similar classes in which students only learned via traditional instruction. We find that students performed significantly better in classes in which the tutorials were used compared to when students learned the material via traditional lecture-based instruction. We thank the National Science Foundation for support.

PST1E24: 9:15-10 p.m. Investigating Grading Beliefs and Practices of Graduate Student Teaching Assistants Using a Rubric

Poster – Ryan T. Sayer, Bemidji State University, 1407 Beltrami Ave NW, Bemidji, MN 56601; rsayer@bemidjistate.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Charles Henderson, Western Michigan University

Edit Yerushalmi, Weizmann Institute of Science

Physics graduate teaching assistants (TAs) are often responsible for grading. Findings of physics education research (PER) suggest that instructors should use grading practices that place the burden of proof for explicating the problem-solving process on students to help them develop problem-solving skills and learn physics. However, TAs may not have learned effective grading practices and may hesitate to take off points if the final answer is correct but the problem-solving process is not explicated. This case study investigated whether TAs apply a PER-inspired grading rubric similar to PER experts and TAs' stated pros and cons of using such a rubric. We also examined whether discussions within a TA professional development course about the benefits of using such a rubric helped TAs shift where they place the burden of proof. Analysis of TAs' written responses, class discussions, and individual interviews suggest that a one-semester intervention was insufficient to change where the TAs placed the burden of proof. We thank the National Science Foundation for their support.

PST1E26: 9:15-10 p.m. Investigating Physics Faculty's Reasoning About Equity in Undergraduate Physics Education

Poster – Angela Little, University of Maryland and Michigan State University, 4101 N. Broadway St. Ste 108, Chicago, IL 60613; angie.little@gmail.com

Chandra Turpen, University of Maryland College Park

We report on a pilot interview study to investigate how junior physics faculty reason about equity in the undergraduate physics student experience. In these interviews, we asked faculty about their knowledge of student experiences with bias, discrimination, and hardship. Faculty were also invited to reflect on the fairness of various common classroom instructional practices. There was a wide range of faculty background and experience in considering equity-related topics. Some faculty described employing innovative strategies to make their classroom environments more inclusive. Other faculty noted struggles with connecting the dots between diversity and research-based instructional practices, despite being on-board with both. The insights gained through this study suggest ways to infuse discussions of inclusive pedagogical practices into professional development focused on research-based instructional strategies.

PST1E27: 8:30-9:15 p.m. Investigating Physics Self-Efficacy of Female African-American Students

Poster – CarriEve A. Horna, The College of New Jersey, 401 Elm Court, Ridgewood, NJ 07450; United States hornac1@tcnj.edu

AJ Richards, The College of New Jersey

In order to better understand the current levels of physics self-confidence of African-American female students, we administered an anonymous survey, composed of quantitative and qualitative responses, about the feelings these students have towards physics. These feelings are important, because they may well influence whether students consider and/or pursue physics as a viable career option. We will discuss the implications of this research for addressing the underrepresentation of African-American females in careers that utilize physics.

PST1E28: 9:15-10 p.m. Investigating Student Reasoning Chains Via Network Analysis*

Poster – J. Caleb Speirs, University of Maine, 5709 Bennett Hall, Orono, ME 04469; caleb.speirs@gmail.com

MacKenzie R. Stetzer, University of Maine

Beth A. Lindsey, Penn State Greater Allegheny

Eric Brewe, Drexel University

Students are often asked to construct qualitative reasoning chains during scaffolded, research-based physics instruction. As part of an ongoing, multi-institutional effort to investigate and assess the development of student reasoning skills in physics, we have been designing tasks that probe the extent to which students can create and evaluate reasoning chains. We have recently reported on a novel online "chaining" task in which students are provided with correct reasoning elements (i.e., true statements about the physical situation as well as correct concepts and mathematical relationships) and are asked to assemble them into an argument that they can use to answer a specified physics problem. This poster will illustrate the role that network analysis techniques may play in extracting meaningful information about student reasoning from these chaining tasks.

* This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432765, DUE-1432052, and DUE-0962805.

PST1E29: 8:30-9:15 p.m. Investigating the Effects of Learning Assistant-Supported Active Learning Environments

Poster – Mary K. Nyaema, Florida International University, 11200 SW 8th St., Miami, FL 33199; mnyaema@fiu.edu

Idaykis Rodriguez, Hagit S. Kornreich Leshem, Laird H, Kramer, Oscar Diaz, Florida International University

Our expanded multi-site study on active learning classrooms supported by Learning Assistants (LAs) aims to understand the connections between three classroom elements: the activity, student learning, and how LAs support the learning process in the classroom. At FIU, LAs are used in a variety of active learning settings, from large auditorium settings to studio classroom with movable tables. With an emphasis on the amount of time spent on active learning in class, we considered factors such as classroom activities, instructional practices, patterns of student engagement and student outcomes. Preliminary results show that LAs spend more time interacting with students in some classes, regardless of the classroom setting, while in other classrooms, LA-student interactions are mostly brief. We will discuss to what extent do activities and instructional practices contribute to student engagement and help them learn.

PST1E30: 9:15-10 p.m. Learning Assessment in a 10-week Introductory Physics Course

Poster – Yuehai Yang, Oregon Institute of Technology, 3201 Campus Dr, Klamath Falls, OR 97601; yuehai.yang@oit.edu

Steven Reed, Oregon Institute of Technology

Binod Nainabasti, Columbia State Community College

David Brookes, California State University, Chico

A challenge-reward assessment cycle is designed for a 10-week introductory physics course at Oregon Institute of Technology, in an effort to improve student learning of a more compacted physics curriculum. Student average learning gains measured by exam retaking are analyzed with multiple factors such as student centrality in an informal learning community, average study time, homework re-dos, and questioning frequency in class. The result of this analysis is useful to identify important factors that contribute to student success in a quarter system.

PST1E31: 8:30-9:15 p.m. Leveraging Students' Intuitions: An Exploration of How Students' Intuitive Ideas About Mechanical Waves Evolve

Poster – Lisa Goodhew, University of Washington, 3910 15th Ave NE, Seattle, WA 98195; goodhewl@uw.edu

Amy D. Robertson, Rachel E. Scherr, Seattle Pacific University

Paula R. L. Heron, University of Washington

In a resources-oriented perspective of student learning, students' intuitive knowledge is viewed as consistent with scientists' ideas in some contexts, and as a foundation for scientific understanding. Resources-oriented instruction seeks to refine and build upon students' intuitive knowledge. We present case studies from exploratory interviews with university students in introductory physics classes. We track the progression of students' ideas over the course of these interviews, examining how their intuitions evolve as they answer questions about mechanical waves. By looking closely at the ideas that students use to solve problems about waves and how these ideas progress, we aim to shed light on how these resources might be leveraged or built on during instruction.

PST1E32: 9:15-10 p.m. Longitudinal Physics Self-Efficacy in Introductory STEM Students

Poster – Rachel Henderson, 135 Willey St., Morgantown, WV 26506; rjhenderson@mix.wvu.edu

John Stewart, Seth Devore, West Virginia University

Lynnette M Michaluk, West Virginia University Center for Excellence in STEM Education

Students' self-efficacy within the general university environment has been shown to play a major role in student success. In the current study, a modified version of the "Self-Efficacy for Learning and Performance" subscale of the Motivated Strategies for Learning Questionnaire was used to measure introductory calculus-based physics students' self-efficacy within the physics classroom. A total of five measurements of students' physics self-efficacy were taken over the course within the fall 2016 semester. Hierarchical linear modeling (HLM) will be used to study the effects of physics self-efficacy on student outcomes: test averages and final grades. The effect of gender and first generation status will also be explored.

PST1E33: 8:30-9:15 p.m. Model-based Inquiry for Teaching Atomic Structure, Quantization and Atomic Spectra

Poster – Tugba Yuksel, Purdue University, 2491 Sycamore. Ln apt 11, West Lafayette, IN 47907-2040; tyuksel@purdue.edu

Lynn A. Bryan, Purdue University

When learning abstract and complicated phenomena in physics, it is quite possible for students to develop non-normative conceptions or incoherent understandings. Researchers have made extensive efforts to analyze students' understandings of various physical phenomena to inform the development of innovative methodologies. Cognitive research suggests that students' models play an essential role in their understanding. Model-based inquiry is an instructional orientation to teaching and learning in which learners have an opportunity to generate, analyze, and/or use models in an inquiry-based learning environment. In this study, we attempted to monitor the evolution of students' models during learning about atomic structure, quantization, and atomic spectra. Using case study approach, we analyzed the evolution of each student's models while engaging with sequence of activities supported with physical, computer–based and mathematical models. The result showed students were able to increase the sophistication of their models and explanation and establish connections between different quantum phenomena.

PST1E34: 9:15-10 p.m. Modeling Student Understanding of Period, Frequency, and Angular Frequency

Poster - Nicholas T. Young, The Ohio State University, 134 West 9th Avenue, Apt B, Columbus, OH 43201; young.1905@osu.edu

Andrew F. Heckler, The Ohio State University

Periodic behavior is a fundamental phenomenon in many physical systems; therefore, it is critical that students understand the concepts and relationships that underlie such behavior. Here, we used the context of the behavior of a simple harmonic oscillator to investigate students' ability to determine the period, frequency, and angular frequency from various mathematical and graphical representations by administering a 36-item test to students in an introductory-calculus-based physics course. We found that students could be classified into one of four groups, according to the question types they mastered. These groups were hierarchically categorized based on the number and kind of relationships each student mastered. For example, we found only students who could correctly apply the period and frequency relationship could also correctly apply any angular frequency relationship. This hierarchical nature of student performance suggests instruction should focus on ensuring that students understand the period and frequency relationship before introducing angular frequency.

PST1E37: 8:30-9:15 p.m. Novice Ideas About the Interaction of Two Electric Charges

Poster – David P. Maloney, Indiana University Purdue University Fort Wayne, 2101 East Coliseum Blvd., Fort Wayne, IN 46805; maloney@ipfw.edu

Catherine Harber, Indiana University Purdue University Fort Wayne

We report on an investigation of how students in an introductory college physics course think about the interaction of two positively charged objects. The students were presented with a sequence of scenarios where various charges and insulating or conducting objects—either charged or electrically neutral—were placed between the two objects. For all scenarios students were asked how hard one of the objects pushed on the other in the new scenario compared to the base case. The results demonstrate that students think the interaction between two charges is altered by various factors. They describe these alterations as resulting from such things as "the force being blocked by the insulator" or "the charge cannot be transmitted by the insulator" or "the charge now has to push on the third charge as well so it doesn't push as hard on the object". We present the patterns found before and after instruction.

PST1E38: 9:15-10 p.m. Participation Rates of In-class vs. Online Administration of Concept Inventories and Attitudinal Assessments

Poster – Xochith M. Herrera, CSU Chico, 1080 Columbus Ave., apt 1. Chico, CA 95926; xochithh@gmail.com

Manher Jiriwala, Jayson Nissen, Ben V. Dusen, CSU Chico

Eleanor Close

We investigated differences in student participation rates between in-class and online administrations of the Force Concept Inventory (FCI), Conceptual Survey of Electricity and Magnetism (CSEM), and the Colorado Learning Attitudes about Science Survey (CLASS). 1,645 students from 3 introductory physics courses over two semesters were instructed to complete the CLASS and the concept inventory relevant to their course, either the FCI or the CSEM. We randomly assigned each student to take one of the instruments in class and the other instrument online using the Learning About STEM Student Outcomes (LASSO) platform at the beginning and end of the course. Results indicated large variation in participation rates across both test conditions (online vs. in class). We will discuss the implications for measuring changes in students' knowledge and attitudes using the two different methods for administering the research instruments.

PST1E39: 8:30-9:15 p.m. Performance on In-class vs. Online Administration of Concept Inventories and Attitudinal Assessments

Poster – Jayson M. Nissen, California State University Chico, 659 SW Jefferson Ave # 2, Corvallis, OR 97333; jayson.nissen@gmail.com

Xochith Herrera, California State University Chico

Manher Jariwala, Boston University

Eleanor Close, Texas State University

Ben Van Dusen, California State University Chico

Measuring student growth and outcomes using concept inventories and affective surveys is a fundamental tool of physics education research. Historically this data has been collected using paper and pencil tests. However, the convenience of computer-based testing has led to many researchers and instructors administering research-based instruments using computers inside and outside of class. We used a stratified random sample of 1,645 students in three physics courses over two semesters to compare performance on concept inventories and affective surveys that were administered either in class as paper and pencil tests or online outside of class using the Learning About Student Supported Outcomes (LASSO) platform. We will discuss implications for these two methods of data collection for measuring changes in students' knowledge and attitudes.

PST1E40: 9:15-10 p.m. Posing Your Own Question; Designing Your Own Investigation

Poster – Danielle Bugge, Rutgers University, 8 Perrine Path, West Windsor, NJ 08550; danielle.bugge@rutgers.edu

Eugenia Etkina, Rutgers University

Over the course of the 2016-2017 school year, high school students learned physics though the ISLE method and engaged in labs that focus on the development of student scientific abilities. Upon completion of mechanics, groups of students had to design experiments to pose their own questions that could be answered with the knowledge they had developed in the first half of the year. The students designed observational, testing, and application experiments. They then selected the scientific abilities that were most applicable to their experiment(s) and wrote a lab report detailing their findings. Based on last year's investigations, we know that high school students are capable of achieving the same or greater proficiency than college students with the scientific abilities when they design experiments to answer questions posed by the teacher. How does this proficiency transfer when students are asked to design experiments to answer their own questions?

PST1E41: 8:30-9:15 p.m Project BoxSand: What Do Students Do When I'm Not Looking

Poster – Kenneth C. Walsh, Oregon State University, 301 Weniger Hall, Corvallis, OR 97331-8507; walshke@physics.oregonstate.edu

Most college handbooks say something along the lines of, students should expect to spend two to three hours per week outside of class studying, per credit hour. So over 60% of the time working is outside the eyes of instructors. Project BoxSand hopes to peer into that outside-of-class study. We scoured the web for the best open resources and created boxsand.org, a site with videos, open-source textbooks, simulations, examples, and more. Students are guided through the resources with a Daily Learning Guide (DLG) and each click is tracked. That data is correlated with performance in the class, FCI gains, and surveys. Do students watch pre-lecture videos before class, before a midterm, or ever and does this correlate to performance in the class? Does following the DLG or going "off-road" have any effect on student outcomes? I will discuss a data set that includes ~ 1 million data points from roughly 450 students.

PST1E42: 9:15-10 p.m. Rethinking Identity: A Framework for Physics Identity that Considers Race

Poster – Simone A. Hyater-Adams, University of Colorado Boulder, 440 S 45th St., Boulder, CO 80305; simone.hyateradams@colorado.edu

Claudia Fracchiolla, Noah Finkelstein, University of Colorado Boulder

Kathleen Hinko, Michigan State University

Systemic and structural oppression within the physics field contribute to the identities and experiences of black physicists. This work adds to the theories of physics identity in order to explicitly incorporate the impacts of racial identity in the process of developing a physics identity. We operationalize the constructs of a physics identity framework in the context of a racial(ized) identity framework. We find that these two frameworks, when operationalized and used together, can elucidate important details in the stories of physicists in the context of their racial backgrounds. The future of this work will discuss broad themes in the experiences of black students, in order to categorize the causes that keep physics culture exclusive of black students specifically, as well as other marginalized populations.

PST1E43: 8:30-9:15 p.m. Semi-formal Modeling in Algodoo

Poster – Elias Euler, Lägerhyddsvägen 1, Uppsala, 75237 Sweden; elias.euler@physics.uu.se*

Bor Gregorcic

Digital tools permeate our everyday lives and, when included alongside traditional laboratory equipment in physics learning environments, they have the potential to supplement the ways in which students interact with physics content. In this study we examine the affordances provided by Algodoo, a two-dimensional digital sandbox software that allows users to model physical phenomena, when it was used alongside a physical laboratory setup as small groups of students completed a physics task. We show how students utilise Algodoo as a 'semi-formal' domain in moving between the physical and formal domains while modeling. Additionally, we find that watching the choices students make in moving between these domains can provide additional insight into how students approach physics tasks.

*Sponsored by Cedric Linder and Bor Gregorcic

PST1E44: 9:15-10 p.m. SIMBA and PUMBA: Surveys for Developing and Measuring Student Buy-in

Poster – Matthew Wilcox, University of Central Florida 4111 Libra Dr - PSB 430 Orlando, FL 32816; mwilcox1@knights.ucf.edu

Jacquelyn J. Chini, University of Central Florida

Studio physics classes typically implement collaborative student-centered instructional techniques that students may not expect when they first come to class. The differences between student expectations and the reality of the studio class can lead to student resistance to these student-centered instructional techniques. Getting students to adjust their expectations to align with the instructional design may be the start of reducing student resistance. Further reduction in student resistance may come from efforts to get students to agree that the studio class format is the best way to learn physics. We refer to the appropriate expectations of and agreement with the class format as "buy-in". We have developed a survey for instructors and another for students to determine successful methods for generating student buy-in. We report on the development of these surveys and how they will be used to determine the best methods for buy-in achievement.

PST1E45: 8:30-9:15 p.m. Smartphone-based Stereoscopic Virtual Reality in Introductory Physics

Poster – Joseph R. Smith, The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; smith.10838@osu.edu*

Christopher Orban, Christopher Porter, The Ohio State University

The use of virtual reality (VR) in instruction has been difficult due to high-cost headsets or "caves", and the challenge of serving entire student populations with only a few such devices. This has changed with the advent of smartphone-based stereoscopic VR. Inexpensive cardboard headsets and smartphones already in students' pockets are the only elements needed for VR learning. We have designed short VR training sessions and studied the utility of this training in the context of electric fields in an introductory physics course at the Ohio State University. The training sessions and cardboard headsets will be available at the poster session. We compare performance on pre-post tests among students trained using VR, those trained using a video of the VR content, and those trained using static 2D images as in a traditional text. We note types of questions where performance seems particularly affected by treatment type.

*Sponsored by Christopher Orban

PST1E46: 9:15-10 p.m. Student Difficulties with Determining Expectation Values in Quantum Mechanics

Poster – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Emily Marshman, University of Pittsburgh

The expectation value of an observable is an important concept in quantum mechanics. However, upper-level undergraduate and graduate students in physics have both conceptual and procedural difficulties when determining the expectation value of physical observables, especially when using Dirac notation. To investigate these difficulties, we administered free-response and multiple-choice questions and conducted individual interviews with students. Here, we discuss the analysis of data on student difficulties when determining the expectation value. We thank the National Science Foundation for support.

PST1E47: 8:30-9:15 p.m. Student Perception of NEXUS/Physics IPLS Labs – TA Retention Implications

Poster – Kimberly A. Moore, University of Maryland, 6525 Roosevelt St., Falls Church, VA 22043; MoorePhysics@gmail.com

UMd-PERG's NEXUS/Physics for Life Sciences laboratory curriculum, piloted in 2012-2013 in small test classes, has been implemented in large-enrollment environments at UMD from 2013-present. These labs address physical issues at biological scales using microscopy, image and video analysis, electrophoresis, and spectroscopy in an open, non-protocol-driven environment. This curriculum exposes students and TAs to new physics concepts pertinent to biological scales and contexts, new pedagogical approaches to student learning, and new technology for data acquisition and analysis. We have had over 50 TAs and over 1500 students complete these labs and this course. In this poster, we will provide a brief overview of what we have learned via student perception. We will discussion the acculturation of teaching assistants to this novel environment and make suggestions for sustainability. Primarily, we make a case for the importance of TA retention in the quality—and the student perception of quality—of the learning environment.

PST1E48: 9:15-10 p.m. Student Understanding of Fourier Series*

Poster – Mikayla N. Mays, California State University, Fullerton, 24305 Sparrow St., Lake Forest, CA 92630; mikayla89@csu.fullerton.edu

Michael Loverude, California State University, Fullerton

Fourier analysis is an important technique for modeling physical systems across the physics curriculum. For this poster, we describe student responses to a variety of problems involving Fourier series, primarily in the context of an intermediate level course in mathematical methods (the so-called 'Boas course'). Tasks center not on procedural knowledge but on conceptual understanding of Fourier series. Typical Fourier tasks present students with a periodic function and ask them to generate a series representation, identifying terms and their associated coefficients. Our tasks instead have asked students, for example, to predict which coefficients will be affected by changes in the periodic function, or to reverse the reasoning; given new coefficients, predict the associated function. Through student responses to these tasks we will highlight the productive, and not so productive, lines of reasoning students use when thinking about problems associated with Fourier series.

*Supported in part by NSF grant PHY#1406035

PST1E50: 9:15-10 p.m. Student Use of Angular Momentum Operators in Quantum Mechanics

Poster – Chrystin E. Green, California State University Fullerton, 800 N State College Blvd., Fullerton, CA 92831; chrystingreen@csu.fullerton.edu

Gina Passante, California State University Fullerton

This study focuses on how students use quantum mechanical operators, specifically operators relating to spin and orbital angular momentum, while taking upper-division quantum mechanics courses. Written exam data is collected and the ACER framework is used to analyze student use of operators in questions that involve commutation relations, expectation values, absolute values and the uncertainty in the angular momentum. We also look at student's choice of representation to solve these problems. The results of this investigation will inform future curriculum.

PST1E51: 8:30-9:15 p.m. Student's Responses to Different Flipped Classroom Approaches

Poster – Steven Wild, University of Findlay, 1000 N. Main St., Findlay, OH 45840; wild@findlay.edu

Heather Yu, University of Findlay

The flipped classroom approach can be a great tool to enhance student learning and success. However, students' perceptions to flipped-classroom teaching greatly impact its effectiveness. End of semester surveys about types of pre-class assignments, lengths of videos, difficulty levels of pre-class quiz questions are conducted. Students' responses in multiple physics courses are collected. The results of these surveys will be presented.

PST1E52: 9:15-10 p.m. Students' Approaches to Sequential and Simultaneous Synthesis Physics Problems

Poster – Bashirah Ibrahim, The Ohio State University, School of Teaching and Learning, 231 Arps Hall, 1945 N. High Street, School of Teaching and Learning, Columbus, OH 43210-1172; bashirah2001@gmail.com

Lin Ding,The Ohio State University, School of Teaching and Learning

Andrew F Heckler, Ryan Badeau, The Ohio State University, Department of Physics

We explored how students tackle sequential and simultaneous synthesis problems. Synthesis problems are tasks combining two or more distinct concepts typically taught in different chapters and are broadly separated in the teaching time-line. Sequential problems describe chronologically occurring events, at different time-points, such that the pertinent concepts can be applied consecutively. Simultaneous problems describe concurrently occurring events, at one time-point, leading to the concurrent application of the pertinent concepts. From students' written solutions and interviews we found that they were able to decompose the sequential tasks into a series of events following the chronological order. This largely facilitated their subsequent problem solving. In contrast, for the simultaneous problems, the students failed to dissect the problem into multiple components and instead treated the situation as a single event. Even after identifying multiple components, some were still uncertain about the connections between them leading to a representation of the actual situation.

PST1E53: 8:30-9:15 p.m. Students' Scientific Reasoning Skills in Physics and Non-Physics Situations

Poster – Bashirah Ibrahim, The Ohio State University, School of Teaching and Learning, 231 Arps Hall, 1945 N. High Street, Columbus, OH 43210-1172; bashirah2001@gmail.com

Lin Ding, The Ohio State University, School of Teaching and Learning

Prior literature has shown that scientific reasoning, a key skill to cultivate among learners at all levels, is a predictor for student content learning. Our work draws on Kuhn's framework which defines scientific reasoning as the conscious intent to seek additional and/or new information with the purpose of improving knowledge and understanding. This framework highlights theory-evidence coordination, an important cognitive process in science practices. Freshman science students, enrolled in an introductory physics course, participated in the study. They completed five open-ended reasoning questions, borrowed from published instruments. Three questions dealt with the topic of energy in the physics context and the other two questions were concerned with domain-general scenarios. We report on (i) the theories and evidence students generated, (ii) their reasons for choosing particular theory and evidence, and (iii) the way they coordinated theories with evidence in both the physics and the non-physics situations.

PST1E54: 9:15-10 p.m. Studio Physics Through the Lens of Universal Design for Learning

Poster – Jacquelyn J. Chini, University of Central Florida, 4111 Libra Drive - PSB 430, Orlando, FL 32816; jchini@ucf.edu

Westley James, Jillian Schreffler, Cherie Yestrebsky, Eleazar Vasquez, III, University of Central Florida

While our community is placing increased emphasis on supporting diverse learners, students with disabilities are rarely in the foreground of these efforts. Students with disabilities now make up more than 10% of students pursuing postsecondary degrees. Our project explores university science courses making use of active learning strategies from the perspective of students with executive function disorders, which is common in several disability diagnoses. While active learning strategies, such as studio physics, have been shown to improve learning and retention for many students, it is unknown what strategies represent support for, or barriers to, particular learners in STEM programs. Universal Design for Learning (UDL) is a framework supporting instructors to design a learning experience that enables all learners to naturally engage with the course, reducing the need for accommodations and supporting learning by all students. In this talk, we explore studio physics courses through the lens of UDL.

PST1E55: 8:30-9:15 p.m. Teachers' Knowledge and Their Use of Representations During Energy Instruction

Poster – Robert C. Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901; robert.zisk@gse.rutgers.edu

Eugenia Etkina, Rutgers University

The knowledge teachers have for teaching a particular subject should be reflected in their instructional practice. In teaching of energy, representations are an important tool helping students analyze energy processes and related phenomena and create mathematical descriptions of these processes. This poster will describe three teachers' understanding of the purpose and use of representations during energy instruction. It will also provide examples from the assignments and assessments that each teacher used during their unit on energy in mechanics to describe how their knowledge of representations is reflected in how they expect students to use such representations in the tasks that they design for instruction.

PST1E56: 9:15-10 p.m. Teaching the Movability of Coordinate Systems: Discovering Disciplinary Affordances

Poster – Trevor S. Volkwyn, Uppsala University, Lägerhyddsvägen 1, Uppsala, 752 37 Sweden; trevor.volkwyn@physics.uu.se*

John Airey, Stockholm University and Uppsala University

Bor Gregorcic, Filip Heijkenskjöld, Cedric Linder, Uppsala University

When students are introduced to coordinate systems in their physics textbooks these are usually oriented in the same manner (x increases to the right). There is a real danger then, that students see coordinate systems as fixed. However, as we know, movability is one of the main disciplinary affordances of coordinate systems. Students worked with an open-ended task to find the direction of Earth's magnetic field. This was achieved by manipulating a measurement device (IOLab) so as to maximize the signal for one component of the field, whilst at the same time keeping the other two components at zero. In the process of completing this task, students came to experience themselves as holding a movable coordinate system. From this point they spontaneously offer elaborations about the usefulness of purposefully setting up coordinate systems for problem solving. In our terms, they have discovered one of the disciplinary affordances of coordinate systems.

*Sponsored by Cedric Linder

PST1E57: 8:30-9:15 p.m. Team-based Strategies for Improving STEM Instruction: Characteristics of Successful Teams*

Poster – Alice R. Olmstead, Western Michigan University, Western Michigan University Kalamazoo, MI 49008; alice.olmstead@wmich.edu

Charles Henderson, Andrea Beach, Western Michigan University

Strategies for improving teaching in higher education have recently begun to shift the focus from individual instructors to the department-level. These department-level change initiatives frequently employ teams. However, literature that explores when teams are likely to be effective mechanisms for improving STEM instruction is limited, and a lack of shared knowledge will likely limit the success of these efforts. Our current work aims to address this shortcoming. In particular, we are synthesizing relevant literature from a variety of domains and considering how these research findings from other contexts could apply here. For example, what is known about the effect of team size on team performance? What types of people should be included on a team? We will use these results to interpret empirical data collected from leaders of team-based STEM change initiatives across the U.S.

*This work is supported by funding from NSF-DUE 1525393.

PST1E58: 9:15-10 p.m. Text Mining LA Discussions in Physics Prep Sessions

Poster – Steven F. Wolf, East Carolina University, Department of Physics, Greenville, NC 27858-4353; wolfs15@ecu.edu

Erica Clark, East Carolina University Depertment of Physics

Eleanor Close, Texas State University

Text-mining techniques have a long history in many disciplines, but there is a struggle to incorporate them into physics due to the ways that physicists embed mathematical equations into their speech. Text-mining algorithms do not have ready methods for identifying equations like "F_net=ma" or "K=1/2 m v^2". We propose a set of rules for including these speech patterns into text-mining applications, and apply these rules to a discussion of introductory physics in a Learning Assistant (LA) prep session. Once these rules have been applied, we will use visualization and quantitative techniques for exploring the themes in different LA groups' discussions.

PST1E59: 8:30-9:15 p.m. The Many Faces of Equity: A Systemic View of Learning Assistant Programs

Poster – Ben Van Dusen, CSU, Chico, 346 Hickory St, Chico, CA 95929

Jayson Nissen, Angelica N. De La Torre, Nancy Caravez, Daniel Caravez, CSU, Chico

Creating equitable outcomes among students is a focus of many instructors and researchers. The term "equity", however, lacks a single unifying definition within our field. In this investigation we examine three definitions of equity and the systemic impact of Learning Assistants (LAs) on each. To do this, we will leverage the statistical power of the Learning About Student Supported Outcomes (LASSO) platform to create Hierarchical Linear Models that include student concept inventory data, student demographics, and course level data from science classes across the country. Implications for the implementation of LA programs and for researchers investigating equity will be discussed.

PST1E61: 8:30-9:15 p.m. The Prevalence of Selected Buoyancy Alternate Conceptions in Two Colleges

Poster – DJ Wagner, Grove City College, 100 Campus Drive, Grove City, PA 16127; djwagner@gcc.edu

While developing a taxonomy of alternate conceptions about buoyancy, we identified over 150 different alternate conceptions. To gauge how prevalent selected conceptions were in the college population, we designed questions to probe those conceptions and asked those questions of students at both the University of Washington and Grove City College. This poster will present on those results.

PST1E62: 9:15-10 p.m. Introductory Astronomy Students' Conceptual Modules of Lunar Phases

Poster – Rebecca Lindel,l Tiliadal STEM Education Lafayette, IN 47901

Adrienne Traxler, Wright State University

Brewe, Bruun and Bearden developed Module Analysis of Multiple Choice Responses (MAMCR) methodology for using network analysis to uncover the underlying conceptual modules of student performance on multiple-choice assessments. The Lunar Phases Concept Inventory (LPCI) assesses students understanding of lunar phases across 8 separate dimensions of understanding based on the results of a detailed qualitative phenomenology of college students' understanding of lunar phases. Unlike many concept inventories, the LPCI has multiple items for each dimension of understanding and each response corresponds to either the scientifically correct answer or to an alternative idea uncovered from the qualitative investigation. In this study, we have combined MAMCR with the database of nearly 2000 LPCI pre-test results. We will report on the different conceptual modules of lunar phases and the relationship of these modules to previous qualitative research.

PST1E63: 8:30-9:15 p.m. Student Unit Vector Resources in Polar Coordinates*

Poster – Marlene Vega, California State University Fullerton, 7055 Paddlewheel Drive, Eastvale, CA 91752; vegamarlene18@gmail.com

Michael Loverude, California State University Fullerton

Warren Christensen, Brian Farlow, North Dakota State University

In upper-division physics courses students work with various coordinate systems, but research has shown that students are less comfortable with non-Cartesian systems. As part of an NSF-supported research and curriculum development project, we have studied student reasoning with coordinate systems and unit vectors across several upper-division physics courses. This study began with a difficulties framework, seeking to document what students were struggling with regarding plane polar coordinates and to address those difficulties to improve instruction. As the study evolved, we found a resources framework more suited to our data, and we instead aimed to identify and describe the resources used by students when answering physics questions regarding unit vectors in polar coordinates. In this presentation we will describe the evolution of our research questions as we probed the extent to which student responses were context dependent. We will present data from written responses and interviews of students in upper division physics courses at two universities.

*Supported in part by NSF grant PHY#1406035

Session DA: Research on the Impacts of the Learning Assistant Model

Location: CC - Breakout 4
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 25
Time: 8:30–10 a.m.

Presider: Valerie Otero

DA01: 8:30-9 a.m. Relationships Between Social Networks and Student Outcomes in Learning Assistant Supported Courses

Invited – Robert M. Talbot, University of Colorado Denver, 1380 Lawrence St., Denver, CO 80217; robert.talbot@ucdenver.edu

Paul Le, Amreen N. Thompson, Leanne Doughty, Laurel Hartley, University of Colorado Denver

One of the primary goals of a Learning Assistant is to promote interaction and discourse among learners working on group-worthy tasks. These interactions are situated within large enrollment courses at the institutions in our research program. We view these courses as learning communities in which social network methods can serve to characterize the centrality, importance, and the positionality of each community member. Using a network analytic approach to responses from student surveys, we quantify these characteristics as parameters which are then be used in regression models. These models relate student and course level attributes to student outcomes, including course grade, concept inventory gain scores, and attitudes towards learning science. In this talk we will describe the central figures in classroom interactions, and the relationships between students' individual network characteristics and their respective outcomes.

DA02: 9-9:30 a.m. The Many Faces of Equity: A Systemic View of Learning Assistant Programs

Invited – Ben Van Dusen, CSU Chico, 2354 Farmington Ave, Chico, CA 95928; bvandusen@csuchico.edu

Jayson Nissen, Angelica De La Torre, Daniel Caravez, Nancy Caravez, CSU Chico

Creating equitable outcomes among students is a focus of many instructors and researchers. The term "equity", however, lacks a single unifying definition within our field. In this investigation we examine three definitions of equity and the systemic impact of Learning Assistants (LAs) on each. To do this, we will leverage the statistical power of the Learning About Student Supported Outcomes (LASSO) platform to create Hierarchical Linear Models that include student concept inventory data, student demographics, and course level data from science classes across the country. Implications for the implementation of LA programs and for researchers investigating equity will be discussed.

DA03: 9:30-10 a.m. Impacts of the Learning Assistant Model on Graduation and Retention

Invited – Jessica Alzen, University of Colorado Boulder, 11061 Gray Street, Westminster, CO 80020; jessica.alzen@colorado.edu*

Valerie Otero, Laurie Langdon, University of Colorado Boulder

Empirical evidence regarding the effectiveness of any intervention is key for program improvement and evaluation, and the Learning Assistant (LA) Model is no exception. This presentation focuses on two lines of inquiry regarding the influence of the LA program at the University of Colorado Boulder--persistence to graduation and course-level D/F/W rates. We use logistic regression models to estimate the effects of exposure to the LA program on six-year graduation rates as well as course failure and withdrawal rates in large gateway STEM courses in two departments at CU Boulder. We find that the LA program has differential effects across departments and that both quantitative and qualitative investigation is necessary to understand the effectiveness of the LA Model. The presentation includes not only the relative results but also provides general information regarding the process for conducting this type of analysis, including an explanation of the models used in the analysis.

*Sponsored by the Learning Assistant Alliance and Valerie Otero

Session DB: Going Public: How to Get Published

Location: CC - Breakout 5
Sponsor: Committee on Physics in Two-Year Colleges
Date: Tuesday, July 25
Time: 8:30–10 a.m.

Presider: Renee Lathrop

DB01: 8:30-9 a.m. I've got a Great Idea for a Book – Now What?

Invited – Diandra Leslie-Pelecky, Trivalent Productions, 11307 Lake Front Court, Bowie, MD 20721; info@drdiandra.com

Most scientists know the steps to publishing in a scientific journal, but what if you want to write for the public? Using my experience with The Physics of NASCAR and my current book project, I'll share a roadmap for pitching, selling, and surviving your science book. I'll focus on the initial stages: evaluating, ,and refining your idea; identifying your audience and competition; getting your idea ready to pitch to an agent; and getting your book proposal ready for your agent to pitch to a publisher. I'll briefly talk about similarities between books and other forms of public outreach including speaking, podcasting, radio, television, and movies. I'll finish with a list of questions you should be able to answer before you start telling everyone "I'm going to write a book".

DB02: 9-9:30 a.m. The Joy and Challenge of Writing for a Broad Audience

Invited – Carl E. Mungan, United States Naval Academy, Physics Mailstop 9c, Annapolis, MD 21402-1363; mungan@usna.edu

Traditionally, faculty job descriptions involve three legs of a stool: teaching, research, and service. I suggest the stool is missing a leg - pedagogy - the scholarship of better understanding the foundations and applications of physics even if they are not directly tied to a course one is teaching or to one's research. Many physicists are interested in pedagogy and have clever ideas they would like to share. However they are not very good at presenting those ideas, especially to nonspecialists. In this talk I will share some opinions about: *motivations for writing broadly*; *sources of inspiration*; *nature of the audience*; *organizing a paper along a storyline*; *the contrast between research and pedagogical articles*; *use of effective diagrams, applications, and demonstrations*; and *making time and energy to write*.

DB03: 9:30-10 a.m. Publishing in Traditional and Non-traditional Formats: Lessons Learned

Invited – Cindy Schwarz, Vassar College, 4 Connelly Drive, Staatsburg, NY 12580; schwarz@vassar.edu

Since 1992, I have published four different titles. Two were with traditional publishers; *A Tour of the Subatomic Zoo: A Guide to Particle Physics* (three different publishers) and Interactive Physics Workbook (2 editions with Prentice Hall). I self-published *Tales from the Subatomic Zoo* (print and e-books) and *Adventures in Atomville: The Macroscope* (a children's book in print, e-books and also in Spanish). Navigating self-publishing, including how to get an isbn and how to do it the most cost effective way can be a challenge. I have lots of advice. I have been through many processes including most recently getting rights back from Springer to publish my *Tour of the Subatomic Zoo: A Guide to Particle Physics* in a third edition with Morgan Claypool through IOP Concise Physics (in color print and ebooks). In this talk I will share what I have learned along the way.

Session DC: The Art and Science of Teaching

Location: Marriott - Covington Ballroom II
Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 25
Time: 8:30–10 a.m.

Presider: Andy Gavrin

DC01: 8:30-9 a.m. Sharing the Beauty of Physics

Invited – David P. Jackson, Dickinson College, PO Box 1773, Carlisle, PA 17013-2896; jacksond@dickinson.edu

As physicists, we find beauty in all areas of physics. Part of the reason for this, I believe, is because physicists see deeply into problems in a way that most students cannot. We see connections and patterns and understand the power of physical theories and the mathematical structure behind them. How can we, as instructors, help students appreciate the power and beauty of physics if they do not have the background—or worse, the interest—to understand these subtle connections? In this talk, I will provide several examples in which the "beauty" of physics arose naturally and unexpectedly while working with students. If we learn to keep an eye out for such situations, we can capitalize on these unexpected learning opportunities and perhaps allow students a glimpse into why we find physics such a fascinating field of study.

DC02: 9-9:30 a.m. Physics as a Transformative Experience for Underrepresented Students

Invited – Valerie K. Otero, University of Colorado Boulder, 249 UCB, Boulder, CO 80309-0249; valerie.otero@colorado.edu

Many efforts have been made to engage the interest of students by making physics relevant to their everyday lives. For decades, "everyday relevance" has appeared in the guise of electric lighting and power systems, skateboard parks, maker-spaces, and other superficial examples of technology's impact on the human experience. What is often forgotten is the everyday relevance that arises as one develops identity and voice within a scientific community—by analyzing and planning, seeing one's hypotheses tested by experiment, and solving new puzzles when expectations are not met. The self-confidence and enhanced social status associated with community engagement can be highly transformative and life changing, with far more impact on one's decision-making abilities and life-directions than sugar-coated technologies used to help students swallow the "castor oil" of physics.* It is physics instructors' responsibility to ensure that students are empowered "through" physics, not in spite of it.

*Idea of sugar and castor oil taken from R.A. Millikan, "Science in the secondary schools," School Science and Mathematics 17, 379-387 (1917).

DC03: 9:30-10 a.m. Physics Course and Department Design – The Science is in the Details

Invited – John Stewart, West Virginia University, 135 Willey St., Morgantown, WV 26506; jcstewart1@mail.wvu.edu

Physics courses and physics programs are complicated systems that must be well designed to provide the best learning experience possible. This talk will examine elements of well-designed classes and discuss the performance of classes that were not optimally designed. Elements such as the selection of assignments, scheduling of tests, class coordination, and multiple instructor coordination will be explored. Physics classes and physics students are situated within physics programs that must also be carefully implemented for both the program and the student to flourish. Important programmatic elements such as advising, degree requirements, and educational activities must work together to create career-knowledgeable students ready to excel both inside and outside of academia. Important places where small programmatic modifications can bring large benefits will be discussed.

Session DD: Developing Successful Mentoring Relationships

Location: CC - Breakout 6
Sponsor: Committee on Women in Physics
Date: Tuesday, July 25
Time: 8:30–10 a.m.

Presider: Anne Cox

DD01: 8:30-9 a.m. Role Model, Mentor, or Friend?

Invited – Nancy J. Easterly, Lone Star College-Greenspoint Center, 16134 Crawford Street, Houston, TX 77040; nj.easterly@nsyt.com

Why did YOU stay in the classroom? The National Commission on Teaching and America's Future estimates that one-third of all new teachers leave after three years, and 46 percent are gone within five years. Did you have a formal mentor, friend, or colleague that made a significant difference in the first years of teaching? How did you come by these relationships that helped you over the 1-5 year "hump"? Have you thought about how you might help a new teacher stay in the classroom? Even after MANY years of teaching, do you still have a mentor? In preparation for this paper, I realized that my first physics mentor was my high school physics teacher, Edwin Paul Heideman. He did "cool" things almost every day. He initially attributed the explanation in a whispery voice, saying, "its magic", but later developed a full blown physics explanation.

DD02: 9-9:30 a.m. Mutual Mentoring: What Works and Why It Is So Valuable*

Invited – Anne J. Cox, Eckerd College, 4200 54th Ave. S, St. Petersburg, FL 33711; coxaj@eckerd.edu

Cindy Blaha, Carleton College

Linda Fritz, Franklin and Marshall College

Barbara Whitten, Colorado College

We were part of an NSF ADVANCE grant mutual mentoring project for senior women faculty in chemistry and physics that began in 2007. We have continued our bi-monthly mentoring meetings for the past 10 years (well beyond the initial grant funding) because of the surprising value we found in having peer mentors. This talk will discuss what seems to have made our mentoring group so long-lasting as well as our initial work to spread this approach to others in the physics community through a new NSF-ADVANCE project: eAlliances- Uniting Isolated Physicists and Astronomers, http://ealliances.aapt.org.

*Support provided by NSF ADVANCE-PLAN D (HRD-1500529) and NSF-ADVANCE PAID (HRD-0619150).

DD03: 9:30-9:40 a.m. Lessons Learned from Facilitating Faculty Online Learning Communities

Contributed – Andy Rundquist, Hamline University 1536 Hewitt Ave Saint Paul, MN 55104-1284 arundquist@hamline.edu

Gillian Ryan, Kettering University

Adrienne Traxler, Wright University

Jeremy Bailin, University of Alabama

Melissa Dancy, University of Colorado

We have facilitated six Faculty Online Learning Communities (FOLCs) in the last two years and have learned many valuable lessons about how best to support, mentor, and cheer on faculty in their first few years of teaching. These FOLCs run for a year after each New Physics and Astronomy Workshop. We'll share some best practices for facilitating online synchronous meetings along with how to couple those effectively with asynchronous communications with the group. We'll talk about issues related to building and sustaining a robust community, helping faculty become more reflective about their teaching, and providing timely support.

DD04: 9:40-9:50 a.m. The Magic of Mentoring

Contributed – Michael J. Ponnambalam, Holy Cross College, Nagercoil, 7-40 Sannathi Street, Vadakkankulam, Tamil Nadu, TN 627116 India; michael.ponnambalam@gmail.com

Teaching is a rare privilege and it offers plenty of opportunities to touch and transform the lives of countless students. And, mentoring is an integral part of teaching. The author's experience in this connection in several countries will be discussed.

DD05: 9:50-10 a.m. Framing the Use and Over-use of Part-time Faculty Positions

Contributed – Dennis Gilbert, Lane Community College, 4000 E. 30th Ave., Eugene, OR 97405; gilbertd@lanecc.edu

Given both the importance and the strong opinions about part-time positions in Two-Year Colleges, productive discussion requires care and thoughtfulness. This paper outlines some productive ways of framing the use and over-use of part-time faculty positions that contribute to faculty unity and make use of data and analytical resources, including the AAPT TYC Guidelines.

Session DE: Technologies

Location: Marriott - Covington Ballroom III
Sponsor: AAPT
Date: Tuesday, July 25
Time: 8:30–9:40 a.m.

Presider: Vasuveda Aravind

DE01: 8:30-8:40 a.m. Cycling Through R&D: Testing Usability of Next Generation Computer Coaches*

Contributed – Emily M. Smith, University of Minnesota 116 Church Street SE, Minneapolis, MN 55455; smithem@umn.edu

Evan Frodermann, Missouri State University

Ken Heller, Leon Hsu, Jie Yang, University of Minnesota

Problem solving is an important component of introductory physics. Using the internet to provide on-demand coaching for students taking this challenging course seems obvious, however, the development of such problem solving coaches is complicated. The C3PO project uses the well-established Deming R&D process to iteratively develop coaches in stages moving continuously between laboratory prototype and in situ testing. This presentation focuses on in situ usability testing at two large research universities. Such testing is also in progress at a two-year college and a state university.

*This work was partially supported by NSF DUE-1504649 and a University of Minnesota Learning Innovations Grant.

DE02: 8:40-8:50 a.m. Factors Influencing Students' Usage of Computer Coaches for Problem Solving

Contributed – Bijaya Aryal, University of Minnesota Rochester, 111 S Broadway, Suite 300, Rochester, MN 55904; baryal@umn.edu

We have incorporated web-based computer coaches to help develop introductory-level physics students' competency in problem solving. This presentation describes the factors that influence students' motivation of using the online system for physics problem solving. Students were interviewed after they completed two sessions of problem solving using the coaches individually. In the interviews students reflected on their experiences about using the coaches. The interview data revealed that students' willingness to use the online system and usage pattern seem to depend on their expectations about online learning resources. Students' degrees of likability of the system found to be determined by their prior mathematics/algebra preparation as well as competency and fluency with computer use. Students' decision on whether to use it or not as an optional resource relies on the time duration for completing the coaches and extent of flexibility in solution paths offered by the online system.

DE03: 8:50-9 a.m. Teaching Computation in Physics Using SageMathCloud

Contributed – Todd Zimmerman, University of Wisconsin - Stout, 410 10th Ave. E, Menomonie, WI 54751; zimmermant@uwstout.edu

SageMathCloud is a free online service that can run SageMath, Jupyter notebooks, and compile Latex documents. SageMathCloud can be used to collaborate with students and colleagues and has class management features built in. Use of the class management features, such as assigning homework, grading homework, and using the peer-grading features in three upper-level physics courses will be discussed.

DE04: 9-9:10 a.m. Triode Tube Operation and Warm Guitar Amplifier Sound

Contributed – David Keeports, Mills College, Department of Chemistry and Physics, Oakland, CA 94613; dave@mills.edu

Why do electric guitar players overwhelmingly prefer the sound of vacuum tube guitar amplifiers? The answer to this question is found in the analysis of how a triode tube amplifies an electric signal. Inputting a low-amplitude sine wave to the tube simply produces a higher-amplitude output that produces a louder sound. But a triode tube can clip a sine wave in two distinct ways. Turning up the input amplitude causes the first type of clipping and produces an asymmetric wave, rich in pleasant even harmonics. Overdriving the tube further additionally produces the second type of clipping. The resulting symmetric wave is then full of potentially dissonant odd harmonics. In this presentation, I will relate the much sought-after warm and rich sound of tube guitar amplifiers to triode tube function.

DE05: 9:10-9:20 a.m. Cyberphysical Experiments: Exploring Affordances and Constrains of Visuohaptic Simulations for Friction Conceptual Understanding

Contributed – Tugba Yuksel, Purdue University, 2491 Sycamore Ln, apt 11, West Lafayette, IN 47907-2040; tyuksel@purdue.edu

Alejandra J. Magana, Purdue University

Constructivist learning approaches suggest that learning occurs best by doing. Physical (PL) and virtual (VL) laboratories are confirmed to be very useful approaches to improve students' conceptual understanding and active engagement. Many studies argue that although PLs implementation provide touch and active involvement factors, VLs are found to be as useful as or better than PLs. In this study, we examined a new type of laboratory called cyberphysical experimentation that aims to integrate affordances of PL (i.e., tactile and kinesthetic elements) with affordances of VL (i.e., rich visualizations) via visuohaptic-simulations. We analyzed students' reasoning and explanations of friction force after engaging with PL, VL and cyberphysical experimentation. Students were probed about their thinking and reasoning in each engagement. We recruited 10 students who have taken at least on physics course. Students were required to complete the assigned task by filling out a worksheet based on their prediction, observations and explanations.

DE06: 9:20-9:30 a.m. Optimal Computational Parameter for Magnetic Simulation

Contributed – Bukyoung Jhun, Seoul National University, Department of Physics and Astronomy, Seoul, Seoul 11210 Republic of Korea; bkjhun93@gmail.com

Youngseok Jhun, Seoul National University of Education

Magnetic field simulation is crucial for the physics engine. However, it hasn't been studied thoroughly. In this study, magnetic simulation was performed under various computational parameters. Results under various parameters were compared with each other, with the analytic solution, and with the experimental results. Suggestion for the optimal parameter is made. This research is expected to be helpful in developing a more physically correct physics engine.

Session DF: Science and Religion

Location: CC - Breakout 7
Sponsor: Committee on History and Philosophy in Physics
Co-Sponsor: Committee on Science Education for the Public
Date: Tuesday, July 25
Time: 8:30–9:10 a.m.

Presider: Charles Winrich

DF01: 8:30-8:40 a.m. Science, Religion and their Cultural Heritages

Contributed – Scott W. Bonham, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101; Scott.Bonham@wku.edu

Both science and religion are human endeavors and therefore culturally embedded. They are both shaped by and shaping their culture and have historical roots in cultures quite different from ours. Understanding those historical contexts can help us make sense of and resolve tensions, which will be illustrated with two examples. First, ancient Near Eastern culture was oral, functionally oriented with a mythological cosmology, which casts the first chapters of Genesis in a different light. Second, the effort of several important Greek philosophical schools to demythologize the world both laid roots for both developing modern science and a materialist philosophy that clashes with religious belief. Knowledge about the cultural heritage of both science and religion gives us a better context to understand areas of tension that stretch back thousands of years.

DF02: 8:40-8:50 a.m. Characteristics of Scientists and Analogous Traits of Christians

Contributed – Bradley K. McCoy, Azusa Pacific University, 901 E Alosta Ave., Azusa, CA 91702-7000; bmccoy@apu.edu

Christian universities present a unique intersection between religious beliefs and intellectual commitments. In this talk, we present examples from a curriculum supplement designed for introductory physics and general education science courses that looks at the characteristics of scientists, comparing and contrasting with traditional Christian characteristics. Throughout the curriculum, the theme of "truth-seeking communities" is emphasized. Parallels in the characteristics of scientists and Christians can help to decrease antagonism between science and Christianity in students.

DF03: 8:50-9 a.m. Developing Student Understanding: A Course in Philosophy and Theology of Science

Contributed – John W. Zwart, Dordt College, 498 4th Ave. NE, Sioux Center, IA 51250; john.zwart@dordt.edu

Carl P. Fictorie, Dordt College

Even within a fairly homogenous religious community there can be significant differences in understanding how religion and science are related. Discussions on topics such as climate change or age of the universe can be polarizing. At Dordt College we use a course, "Perspectives in Physical Science," required of physics and chemistry majors and serving others as a core course, to increase our students' knowledge and understanding of issues relating science and religion while respecting their prior understanding and convictions. Topics explored in the course range from fundamental issues regarding the nature of science, to surveying the various philosophical and theological traditions which are used to frame scientific inquiry, to discussing how science can be a genuine calling for Christians. This course, including its goals, major topics, and methods of instruction will be discussed.

DF04: 9-9:10 a.m. Newtonian Theism and Newtonian Mechanics

Contributed – James Simmons, Shawnee State University, 920 Second Street, Portsmouth, OH 45662; jsimmons@shawnee.edu

Isaac Newton created a very extensive record of his (unorthodox) theological and biblical speculations. But is there any reason to believe that this influenced his scientific thinking? And did his scientific thinking influence his religious thought? Does any of this help us to understand how science and religion interact today?

Session DG: Introductory Courses

Location: CC - Breakout 8
Sponsor: AAPT
Date: Tuesday, July 25
Time: 8:30–9:50 a.m.

Presider: Matthew Vonk

DG01: 8:30-8:40 a.m. Application of Team-based Learning to a First Semester IPLS Course

Contributed – Brokk K. Toggerson, University of Massachusetts, Amherst 666 N. Pleasant St #133, Amherst, MA; 01003-0001 toggerson@physics.umass.edu

Heath Hatch, Christopher Ertl, Paul Bourgeois, University of Massachusetts, Amherst

We present the current status of an effort at UMass, Amherst to transition the first semester of our large IPLS course to a team-based learning format following Michaelsen et al while simultaneously adjusting the topics and skills covered to apply to our population. We will present our motivations for the transition, key features of our course's structure, and an overview of the largest departures in content from a typical algebra-based introductory course. Future data analysis plans and sharing through the IPLS portal will also be touched upon.

DG02: 8:40-8:50 a.m. Using an Explore-first Strategy in Introductory-level Courses

Contributed – Raymond Chastain, University of Louisville, Department of Physics & Astronomy, Natural Science 102 Louisville, KY 40292; rjchas01@louisville.edu

Joanna Weaver, University at Albany, State University of New York

Marci DeCaro, Daniel DeCaro, University of Louisville

One instructional practice we use in engaged classrooms is having students work with a conceptual exercise that allows them to wrestle with their understanding of a certain topic after they have received instruction on the concept. Over several semesters, we have investigated how the same activity could be used before instruction, giving students the opportunity to explore a concept prior to receiving explicit instruction over it. We will present theoretical reasons supporting this practice, both from the perspectives of cognitive psychology and course development. We will also discuss some of the lessons we have learned in using an explore-first approach and summarize the data we have collected to analyze its utility.

DG03: 8:50-9 a.m. Using Discourse Analysis to Inform Design of Introductory Physics Tutorials

Contributed – Hannah C. Sabo, University of Maryland, 66 Walnut Ave., Takoma Park, MD 20912; hsabo13@gmail.com

Students benefit from the use of PhET interactive simulations in their physics classes. However, research-based tutorials that incorporate PhET simulations might help students learn even more. This project seeks to develop, test, and iteratively refine tutorials for introductory physics that pair with PhET simulations. Our "testing" includes videorecording small groups of students using the tutorials. In this presentation, I argue that using tools from discourse analysis to get a sense of how students are framing their activity as they work through the tutorial can inform productive modifications in the tutorial—modifications that pre-post testing alone would not have suggested.

DG04: 9-9:10 a.m. Investigating the Effects of Learning Assistant-Supported Active Learning Environments

Contributed – Mary K. Nyaema, Florida International University, 11200 SW 8th St., Miami, FL 33199; mnyaema@fiu.edu

Idaykis Rodriguez, Hagit Leshem, Laird Kramer, Oscar Diaz, Florida International University

Our expanded multi-site study on active learning classrooms supported by Learning Assistants (LAs) aims to understand the connections between three classroom elements: the activity, student learning, and how LAs support the learning process in the classroom. At FIU, LAs are used in a variety of active learning settings, from large auditorium settings to studio classroom with movable tables. With an emphasis on the amount of time spent on active learning in class, we considered factors such as classroom activities, instructional practices, patterns of student engagement and student outcomes. Preliminary results show that LAs spend more time interacting with students in some classes, regardless of the classroom setting, while in other classrooms, LA-student interactions are mostly brief. We will discuss to what extent do activities and instructional practices contribute to student engagement and help them learn.

DG05: 9:10-9:20 a.m. First-Year Research and Writing Course for Physics Majors

Contributed – Briana L. Fiser, High Point University, One University Parkway, High Point, NC 27268; bfiser@highpoint.edu

We have developed a yearlong one-credit course called Research and Scientific Writing in Physics to give first and second year physics majors the opportunity to "do" science at the start of their college careers and to establish a scientific learning community among our majors. Students learn to search for, read, and analyze scientific literature; write concisely and scientifically; collaborate in teams to develop a research question and design an experiment; prepare research proposals; carry out their experiments; present their results in poster and oral presentations; and write research articles. For the experimental component, students are assigned one of five physics faculty members as a mentor, further fostering relationships between our first year majors and physics faculty. Additionally students use their learning experiences in this course as a springboard for future opportunities in research. The structure of this course and growth in our program as a whole will be discussed.

DG06: 9:20-9:30 a.m. Estimating Error from False Positives of the Force Concept Inventory

Contributed – Michael M. Hull, 1111 Main St., Wayne, NE 68787; mihull1@wsc.edu

Jun-ichiro Yasuda, Yamagata University

Masa-aki Taniguchi, Meijo University

Naohiro Mae, Kansai University

We are interested in quantifying the validity of the Force Concept Inventory (FCI) as a systematic error and analyzing its behavior. A modified version of the FCI was administered to 513 university students in Japan in 2015. In addition to the 30 original questions, subquestions were introduced for three questions that, according to prior research, elicit false positives from students (6, 7, and 16) as well as for question 5. Using logistic regression with the results of question 5 and its subquestions, we estimate the systematic error arising from the remaining 26 questions. Our results indicate that true score can be lower than half of the raw score for the Japanese students. In this presentation, we will elaborate on our methodology and research findings, and present our preliminary data from students in the U.S. with the recent English version of this modified FCI.

DG07: 9:30-9:40 a.m. The Physics of Music

Contributed – Stephen C. Parker, Saint Martin's University, 5000 Abbey Way SE, Lacey, WA 98503; sparker@stmartin.edu

Darrell Born, Saint Martin's University

Last year at Saint Martin's University, we developed a new general education course for our curriculum entitled "The Physics of Music." The class, co-taught by both a music professor and a physics professor, gave students the option of taking the course to fulfill either a core requirement in the Fine Arts or a core requirement in the Laboratory Sciences. Although our first run through the class had a relatively small population, we had approximately equal numbers of music and science students taking the class. We were very pleased with the outcomes from the class and plan to offer this course again in the future. I will talk about some of the lessons learned during our first experience with this class and comment about some of the interdisciplinary discussions that occurred in the course.

DG08: 9:40-9:50 a.m. Project-based Learning in Introductory Physics

Contributed – Gabriela Popa, Ohio University Zanesville, 1425 Newark Rd., Zanesville, OH 43701; gabiapopa@yahoo.com

Project based learning have caught the attention of science educators. I have used this approach in the introductory physics classroom by offering the students this option as an extra credit. After the laboratory techniques and software used for data analysis are introduced in the classroom for several weeks into the semester, students design and carry on a project for several weeks. They use the same data analysis steps as in previous laboratory experiments. Students check their progress with the instructor from time to time. At the end of the semester students will present their experiments in a 10-minute presentation. By working on projects, students started to improve participation and motivation during the introductory physics laboratories and to appreciate the importance of the scientific process. This also helped students take ownership and learned not only the physics concepts but also to present their results.

Session DH: Upper Division/Graduate Courses

Location: CC - Breakout 9
Sponsor: AAPT
Date: Tuesday, July 25
Time: 8:30–9:30 a.m.

Presider: TBA

DH01: 8:30-8:40 a.m. Graduate and Upper-Level Undergraduate Response to a Flipped, Active-Engagement Class

Contributed – Ramon E. Lopez, The University of Texas at Arlington, Deprtment of Physics, Arlington, TX 76019; relopez@uta.edu

Michael Greene, The University of Texas at Arlington

Ximena Cid, California State University Dominguez Hills

The use of flipped classrooms and active engagement techniques is becoming increasingly widespread in introductory undergraduate science courses. In this presentation I will discuss the use of a flipped classroom and active engagement in advanced undergraduate dynamics and graduate classical mechanics. Students in these classes have been surveyed to determine their reaction to this approach to instruction, and we will present the survey results. In addition, an experimental sample class with advanced graduate students was used to determine their reaction to active engagement techniques in a classroom setting. The results are that advanced physics students respond well to active learning in the classroom, but that the response to the flipped classroom was mixed. Moreover, there is some evidence from several years of graduate qualifying exams that student success on the classical mechanics portion of the exam was superior after the introduction active learning techniques in the class.

DH02: 8:40-8:50 a.m. Bridging the Discrete to the Continuum Gap in Quantum Mechanics*

Contributed – Charles Joseph DeLeone, California State University, San Marcos 333 S. Twin Oaks Valley Rd., San Marcos, CA 92096-0001; cdeleone@csusm.edu

Upper-division physics students often struggle with quantum concepts during their first exposure to full-blown quantum mechanics. Research into student learning suggests that one area of difficulty is the transition from discrete states to the continuum such as is experienced in a "Spins First" curriculum. This talk will focus on various approaches available to instructors to bridge this gap. This includes a discussion of how vector based computational tools such as Matlab can be used a means of smoothing this transition, along with results from a pilot project involving the use of such tools.

*Partially supported by NSF DUE #1068477

DH03: 8:50-9 a.m. A Quantum Measurement Game for Undergraduates

Contributed – Theodore A. Corcovilos, Duquesne University, 600 Forbes Ave., 317 Fisher Hall, Pittsburgh, PA 15282-0001; corcovilost@duq.edu

Quantum mechanics defies students' long-learned classical intuition about how the world works. Building new quantum intuition about the probabilistic nature of measurements and the nature of incompatible measurements is a key challenge for instructors. Here I present a dice-based simulation of measuring the spin of a spin-1/2 particle that is appropriate for an undergraduate Modern Physics survey course or an introductory Quantum Mechanics course. The simulation is presented as a game in which the students try to guess an unknown quantum state using the fewest number of measurements. The game teaches the students about the probabilistic nature of quantum states and quantum measurement, and is a gateway to advanced statistical methods such as maximum likelihood estimation and Bayesian estimation.

DH04: 9-9:10 a.m. Student Difficulties with an Asymmetric Well in Graduate Quantum Mechanics

Contributed – Christopher D. Porter, The Ohio State University, 1005 Physics Research Building, 191 W Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Andrew F. Heckler, The Ohio State University

Abigail M. Bogdan, Seton Hill University

In our work with physics graduate students at The Ohio State University, we have examined several prevalent misunderstandings that persist well into graduate level quantum mechanics. Here we focus on difficulties in drawing bound states in an asymmetric well. Difficulties in drawing bound states were noted at the graduate level as early as 2008, by C. Singh. In our study we find many of the same startling student mistakes reported at that time. But we find the asymmetric well reveals a new set of misunderstandings related to the fundamental misuse of axes and symmetry, and new student mistakes including drawing discontinuous wavefunctions and first derivatives. In some cases, the asymmetry of the well also brought to light student misunderstanding about the meaning of a stationary state. We present data collected over three years, through both pre-post testing and in student interviews.

DH05: 9:10-9:20 a.m. Utilizing Letters to Investigate Students Ability to Communicate Physics

Contributed – Charles L. Ramey II, Texas Tech University, Physics & Astronomy Dept, Box 41051, Lubbock, TX 79409; United States charles.ramey@ttu.edu

Beth Thacker, Texas Tech University

The Modern Physics lab at Texas Tech University has become a bridge for the introductory- to advanced-lab experience in which students learn conceptual, experimental and observational skills. Our research focuses on a project called "Letters Home" (LH) in which students are practicing scientific writing skills in the form of casual letters to a non-physicist and matriculating to a scientific audience. We are analyzing 154 letters written by students to a multi-faceted audience (ranging from parents to physics professors). The American Association of Physics Teachers (AAPT) offered recommendations for the lab curriculum in which we have incorporated 3 into the modern physics lab. We will be assessing how LH aligns with these recommendations as well as characterizing the way students engage with various audiences. We are also developing a coding scheme through which we can analyze students' skills and competence in communicating physics using the LH method.

DH06: 9:20 -9:30 a.m. Examining Student Understanding of Diode Circuits in Physics and Engineering*

Contributed – Kevin L. Van De Bogart, University of Maine, 120 Bennett Hall, Orono, ME 04469; kevin.vandebogart@maine.edu

MacKenzie R. Stetzer, University of Maine

Christos P. Papanikolaou, University of Athens

As part of ongoing research on the learning and teaching of analog electronics, we have been examining student understanding of diode circuits after relevant instruction in electronics courses offered in electrical engineering and physics departments. Major goals of this work are to probe the extent to which the nature of student understanding (including the prevalence of specific difficulties) depends upon the disciplinary context, and in turn to use the findings to strengthen instruction in courses in both disciplines. Free-response written tasks developed by physics instructors and by engineering instructors have been used to probe student understanding of basic diode circuits. Findings from these tasks will be presented and implications for instruction will be discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1323426, DUE-1022449, and DUE-0962805.

Session DI: Introductory Labs/ Apparatus

Location: Marriott - Covington Ballroom I
Sponsor: AAPT
Date: Tuesday, July 25
Time: 8:30–9:40 a.m.

Presider: TBA

DI01: 8:30-8:40 a.m. Writing and Deploying Your IOLab Software (Python) and Firmware (C++)

Contributed – Mats A. Selen, University of Illinois, Department of Physics 1110 W. Green St., Urbana, IL 61801; mats@illinois.edu

IOLab is an inexpensive wireless data acquisition tool, developed by physics education researchers with the goal of enabling high quality experimentation anywhere. Both the pedagogy and content being developed for IOLab are discussed in other session of this meeting. In this presentation I will describe a recently developed open source Python library that allows users to control all aspects of the IOLab hardware. I will also discuss how users can modify the IOLab C++ firmware using freely available development tools, and how this can be loaded into the device using a simple over-the-air reprogramming tool.

DI02: 8:40-8:50 a.m. A Fan-tastic Quantitative Exploration of Ohm's Law

Contributed – Robert Charles Ekey, University of Mount Union, 1972 Clark Ave., Alliance, OH 44601-3993; ekeyrc@mountunion.edu

Brandon Mitchell, West Chester University

Andrea Edwards, Roy McCullough, William Reitz, University of Mount Union

Recently, we demonstrated small computer fans are a suitable replacement of tungsten filament bulbs for qualitative analysis of simple circuits where the current is related to the rotational speed of the fan.[1] In this presentation, we demonstrate that fans can be used for quantitative measurements as well. Ohm's law can be verified from measurements of the voltage across and current through the fan, which exhibits a linear relationship enabling an effective resistance of the fan to be calculated. These can then be verified for series, parallel and combination circuits containing one or two fan models. Though the fan is a complex circuit element, these results demonstrate both the qualitative and quantitative benefits of using fans as an effective tool to teach simple circuits. As bulbs do not allow for these simplistic quantitative measurements, fans are arguably a suitable, if not better, replacement for light bulbs.

1. Robert Ekey, Andrea Edwards, Roy McCullough, William Reitz, and Brandon Mitchell, *The Physics Teacher* **55**, 13 (2017).

DI03: 8:50-9 a.m. Designing Earthquakes for a Low-Cost Shake Table*

Contributed – Frederick J. Thomas, Math Machines, 1014 Merrywood Dr., Englewood, OH 45322; fred.thomas@mathmachines.net

Robert A. Chaney, Marta Gruesbeck, Sinclair Community College

A servo-powered shake table can be programmed to produce one-dimension scale versions of either real or user-designed earthquakes. Programmed using Excel-like algebraic functions, the table can replicate earthquakes with varying amplitudes (i.e., original Richter magnitude), different maximum accelerations (the primary basis for building codes), varying frequencies, alternative waveforms and more. In addition to teaching about the differences among displacement, velocity and acceleration, the table can assist in teaching about periodic and non-periodic motions. A sample two-part activity asks students to (1) design and build a structure that can withstand a Richter magnitude 5 earthquake, then (2) design a magnitude 4 earthquake to destroy the structure. Since the Arduino family board incorporates a micro SD card, the system can store and replay thousands of alternative motions. Plans for building the table are provided, along with an executable LabVIEW control program and the necessary sketch for implementation via a ChipKIT WF32 board.

*Based in part on NSF-ATE Grants No. DUE-0202202 and DUE-1003381

DI04: 9-9:10 a.m. Inquire into Optical Tunneling in Introductory Physics Lab of Fudan

Contributed – Shihong Ma, Department of Physics, Fudan University, 220 Handan Road, Shanghai, SH 200433 China; shma@fudan.edu.cn

Zeben Xiong, School of Mathematics and Physics, Jingchu College of Science and Technology

In this paper, theoretical evidences of the evanescent field and its properties field are analyzed. Through the review and the analysis, the corresponding evanescent wave transmittance formula is obtained. Theoretically, the relationship between transmittance and the thickness of the gap, the one between the wavelength of the incident light and the angle of incidence, are simulated in the computer. Experimentally, the relationship between the transmittance and the thickness of the gap is proved to exist.

DI05: 9:10-9:20 a.m. Using Lab Notebooks to Examine Students' Engagement in Modeling in an Upper-Division Electronics Lab Course

Contributed – Heather Lewandowski, University of Colorado, CB 440, Boulder, CO 80309; lewandoh@colorado.edu

Jacob Stanley, University of Colorado

Weifeng Su, Fudan University

We demonstrate how students' use of modeling can be examined and assessed using student notebooks collected from an upper-division electronics lab course. The use of models is a ubiquitous practice in undergraduate physics education, but the process of constructing, testing, and refining these models is much less common. We focus our attention on a lab course that has been transformed to engage students in this modeling process during lab activities. The design of the lab activities was guided by a framework that captures the different components of model-based reasoning, called the Modeling Framework for Experimental Physics. We demonstrate how this framework can be used to assess students' written work and to identify how students' model-based reasoning differed from activity to activity.

DI06: 9:20-9:30 a.m. The Paschen Curve – A Culminating Project for a Vacuum Lab

Contributed – Dallin S. Durfee, Brigham Young University, N245 ESC, Provo, UT 84602; dallin_durfee@byu.edu

David D. Allred, Nathan D. Powers, Brigham Young University

BYU's advanced lab aims to develop in students the habits of applying logical, systematic thinking to experimental work; the same skills they use in conventional classrooms. While there are many specific skills they could learn, optics, data capture, and vacuum technology are widely used in physics. In physics 245 (advanced lab), pairs of students design and build a turbo-pumped high vacuum system from components. Skills developed include: asking how can I heard this equipment and how can it hurt me, finding leaks logically, using pressure transducers, understanding the difference between absolute and relative transducers, the techniques for zeroing and spanning meters, and computer data collection. Determining the Paschen curve for various pure gases and gas mixtures provides a good opportunity to bring together the various skills they have been learning as a unit final project, since they must also learn to use high voltage safely.

DI07: 9:30-9:40 a.m. Construction of Comprehensive Experimental Platform Based on Spatial Light Modulator*

Contributed – Raohui Feng, Sun Yat-sen University, No. 135, Xingang Xi Road, Guangzhou, 510275 China; fengrhui@mail.sysu.edu.cn

Han Shen, Deju Liao, Xintu Cui, Yizhong Fang, Sun Yat-sen University

With the development of mirco/nano-photonics, optics experiment teaching has encountered much more challenge in instructional design for college physics experiment. In traditional optical experiments, a variety of optical elements such as lens, wave plate, diffractive elements and spatial filters are needed and most of the parameters of these elements are fixed. We propose a plan to construct the comprehensive experimental platform based on spatial light modulators (SLMs), which are used extensively in the field of optical information processing, such as optical imaging and displaying, adaptive optics, and computer-generated hologram. We replace the traditional optical elements by SLM, and demonstrate the design more flexible in adjusting the variable quantity parameters and enrich content for experiment projects. These experiment projects can be extended easily and integrated into a module. Therefore our comprehensive experimental platform has the characteristics of flexibility, expansibility, innovation and frontier to practice.

*This project is supported by J1210034 & J1110094.

Session DK: Interactive Lecture Demonstrations: Whats New? ILDs Using Clickers and Video Analysis

Location: CC - Breakout 10
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Educational Technologies
Date: Tuesday, July 25
Time: 8:30–10 a.m.

Presider: Priscilla Laws

DK01: 8:30-9 a.m. ILDs in Electric Circuits and Optics: Active Learning in Lecture Including Clickers and Video Analysis

Invited – David R. Sokoloff, University of Oregon, Department of Physics, 1274 University of Oregon, Eugene, OR 97403-1274, sokoloff@uoregon.edu

Ronald K. Thornton, Tufts University

The results of physics education research and the availability of microcomputer-based tools have led to the development of the Activity Based Physics Suite.[1] Most of the Suite materials are designed for hands-on learning, for example student-oriented laboratory curricula such as RealTime Physics. One reason for the success of these materials is that they encourage students to take an active part in their learning. This interactive session will demonstrate through active audience participation Suite materials designed to promote active learning in lecture—Interactive Lecture Demonstrations (ILDs) (2), including those using clickers and video analysis. The examples of ILDs in this session will be from electric circuits and optics.

1. E.F. Redish, Teaching Physics with the Physics Suite (Wiley, Hoboken, NJ, 2004).
2. David R. Sokoloff and Ronald K. Thornton, Interactive Lecture Demonstrations (Wiley, Hoboken, NJ, 2004).

DK02: 9-9:30 a.m. Interactive Lecture Demonstrations: Effectiveness in Teaching Concepts

Invited – Ronald K. Thornton, Tufts University, 12 Temple Street, Medford, MA 02155; sokoloff@uoregon.edu,ronald.thornton@tufts.edu

David Sokoloff, University of Oregon

The effectiveness of Interactive Lecture Demonstrations (ILDs) in teaching physics concepts has been studied using physics education research based, multiple-choice conceptual evaluations.[1] Results of such studies will be presented, including studies with clicker ILDs. These results should be encouraging to those who wish to improve conceptual learning in their introductory physics course.

1. David R. Sokoloff and Ronald K. Thornton, "Using Interactive Lecture Demonstrations to Create an Active Learning Environment," Phys. Teach. 35, 340 (1997).

Session DL: PER: Modeling Student Engagement

Location: CC - Ballroom D
Sponsor: AAPT
Date: Tuesday, July 25
Time: 8:30–9:40 a.m.

Presider: Zahra Hazari

DL01: 8:30-8:40 a.m. Alike or Unalike: A Comparison of Physics and Engineering Undergraduates

Contributed – Tyler Scott, Northwestern College, 101 7th Street SW, Orange City, IA 51041; tyler.scott@nwciowa.edu

Riley Harder, Northwestern College

Studies of undergraduate students often lump physics and engineering students together. And, especially at small, four-year colleges, engineering students are often housed in physics departments. While superficially similar, the fields of physics and engineering have different histories, purposes, and ways of thinking. This study investigates the attitudes of physics and engineering students attending four-year, liberal arts colleges. It identifies similarities and differences among them in two aspects. First, we are interested in how they compare in their interdis-

Awards Session

Location: CC - Event Center II
Date: Tuesday, July 25
Time: 10:30 a.m.–12 p.m.

Presider: Janelle M. Bailey

Ken Heller, University of Minnesota

2017 Robert A. Millikan Medal: presented to Ken Heller

Can We Get There from Here?

The AAPT was founded on the recognition that the progress and support of physics required improved physics instruction. Almost 90 years later, that is still our mission and we have come to recognize the complexity of the problem. There is now a reasonable understanding of the goals of physics instruction and why it needs improving. Efforts within the past half century have produced multiple examples of instruction that demonstrably meet many of those goals. Those pedagogies result in educational improvement because they have a foundation anchored in modern learning theory and neuroscience, often recognized in retrospect. However, despite their proven effectiveness, these modern pedagogies have had minimal impact on physics instruction throughout the country. Too often only their surface features survive when they are adopted beyond isolated outposts on the educational map. Even when adopted with fidelity, their implementation is often snuffed out by changing personnel, constraints, or shifting instructional priorities. This talk explores the current reality and examines practical possibilities that could lead to widespread and lasting effects within the next half century.

2017 AAPT Fellowships Presented to:

Jon Anderson, **Centennial High School, Minneapolis, MN**
Dolores Gende, **North Broward Preparatory School, Coconut Creek, FL**
Kenneth Heller, **University of Minnesota, Minneapolis, MN**
Ramon E. Lopez, **University of Texas, Arlington, TX**
Frank P. Noschese, **John Jay High School, Cross River, NY**
Bob Powell, **University of West Georgia, Carrollton, GA**
J. Mark Schober, **Trinity School, New York City, NY**
Cindy Schwarz, **Vassar College, Poughkeepsie, NY**

ciplinary affinities. A second, related question is what goal orientations these students have. By looking at these two characteristics of physics and engineering students, we hope to better understand what they want from their undergraduate education and how educators can better serve them.

DL02: 8:40-8:50 a.m. Longitudinal Analysis of Identity Trajectories of Undergraduate Physics Students

Contributed – Gina M. Quan, University of Maryland, College Park, 082 Regents Drive, College Park, MD 20740; gina.m.quan@gmail.com

Chandra Turpen, Andrew Elby, University of Maryland, College Park

In this talk, we analyze the longitudinal development of students' identity trajectories as undergraduate physics majors. Students in the study participated in an elective seminar in which they were paired with graduate student and faculty mentors on physics research projects and participated in a weekly discussion about research. Using video data from student interviews, classroom observations, mentor interviews, and research observations, we study students' research experiences and their experiences in the departmental physics community. Our analysis draws on sociocultural theories of learning to consider what the process of legitimization and delegitimization of students' physics identities looks like over time. In particular, we attend to how relationships between students and other members of the physics community impact their participation.

DL03: 8:50-9 a.m. Physics Major Engagement and Persistence: A Phenomenography Interview Study

Contributed – Eric A. Williams, Florida International University, 11200 SW 8th St., Miami, FL 33199; ewill085@fiu.edu

Eric Brewe, Drexel University

Justyna P. Zwolak, Remy Dou, Florida International University

Over an eight-year period, physics graduation rates at Florida International University (FIU) increased 400% relative to the institution as a whole.[1] To shed light on this phenomenon we conducted an interview study of upper division physics students to learn about their experiences, successes, and challenges. We interviewed 10 students with a semi-structured interview protocol based on the student engagement and persistence work of Tinto and Nora. We then performed a phenomenography study of the recorded interviews. Phenomenography is defined as "a research method for mapping the qualitatively different ways in which people experience, conceptualize, perceive, and understand various aspects of, and phenomena in, the world around them."[2] We present results from this study that describe the experience of physics majors at FIU in terms of recurring themes, salient points, challenging obstacles, and inspiring successes about their engagement and persistence in the physics major.

[1] Brewe, E., Kramer, L., & Sawtelle, V. (2009). Investigating student communities with network analysis of interactions in a Physics Learning Center. AIP Conference Proceedings, 1179, 105–108. http://doi.org/10.1063/1.3266688 [2] Marton, F. (1988). Phenomenography: A research approach to investigating different understandings of reality. Qualitative Research in Education: Focus and Methods, 21, 141-161.

DL04: 9-9:10 a.m. Building Success; Designing for Growth in DATA Lab*

Contributed –William M. Martinez, Michigan State University, 1310B BPS Building, East Lansing, MI 48824; marti790@msu.edu

Marcos D. Caballero, Michigan State University

Since the development of the AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum, curriculum design in laboratory courses has been increasingly focused on developing experimental skills and practices. Although many laboratory transformations share the same goal, the structures and supports within the course differ vastly. A newly transformed introductory physics lab curriculum at Michigan State University, Design, Analysis, Tools, and Apprenticeship (DATA) Lab, has been designed to emphasize growth in a student's experimental skills. In this talk, the strategies and practices that we employed to scaffold experimental techniques and to provide support for student growth will be presented. Further, we will discuss how these design features afford students an opportunity to recognize their abilities and role in an experimental setting.

*This work is funded by a Howard Hughes Medical Institute Science Education Grant

DL05: 9:10-9:20 a.m. Do Student Learning Communities Promote Interactions? A Social Network Analysis

Contributed – Alexis Knaub, Western Michigan University, 1908 W. Michigan Ave., Kalamazoo, MI 49008; avknaub@gmail.com

Charles Henderson, Western Michigan University

Jenifer Saldanha, Iowa State University

We studied three student learning communities for undeclared undergraduate students at a large research university. One of the purposes of these communities was to introduce students to a variety of STEM majors and encourage them to declare a STEM major by providing them opportunities to interact with faculty and instructional staff to deepen their understanding of STEM. However, the extent to which these interactions occur and their benefits for students is unclear. We used social network analysis (SNA) to understand the community structure of these learning communities and whether interactions were linked to desired outcomes such as academic and social support.

DL06: 9:20-9:30 a.m. Gateways ND: Assessing Faculty Perceptions of Active Learning*

Contributed – Alistair G. McInerny, North Dakota State University, 1340 Administration Ave., Fargo, ND 58102; Alistair@Mcinerny.org

Mila Kryjevskaia, Jared Ladbury, Paul Kelter, North Dakota State University

A North Dakota State University team of faculty is designing, implementing, and evaluating a sustainable campus-wide professional development program to help faculty maximize instructional effectiveness by building expertise in student-centered teaching practices. Several workshops, along with regular weekly meetings of the Faculty Learning Communities, are being developed to promote active learning methodologies across campus. The Theory of Planned Behavior has been used in order to investigate participants' intentions, attitudes, norms, and control beliefs about the use of active learning in their instruction. Faculty responses to surveys administered at several points throughout the course of the professional development program provide insight into participants' development of expertise with active learning and highlight the importance and effect of the professional development. Results from two cohorts of participants will be reported. Implications for the development and implementation of campus-wide professional development programs will be discussed.

*This material is based upon work supported by the National Science Foundation under Grant No. DUE-1525056.

DL07: 9:30-9:40 a.m. Saving the Best for Last: Introductory Physics as a Capstone

Contributed – Benjamin Geller, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu

Catherine H. Crouch, Swarthmore College

When is the appropriate time for life science students to take a course in introductory physics? Proponents of the "physics first" philosophy argue that the quantitative skills developed in introductory physics are important for students' later coursework in biology and chemistry. On the other hand, a "physics last" model allows Introductory Physics for Life Sciences (IPLS) instructors to ground physical models in authentic biological and biochemical contexts with which the students are already familiar, and about which they may already have authentic driving questions. We will present attitudinal survey and case-study interview data from an Introductory Physics for Life Sciences (IPLS) that is populated by students at various stages of their undergraduate career. We will describe how the level of student engagement with IPLS curricular material is dependent on the students' prior coursework experiences, and thereby describe some of the strengths and limitations of the "physics last" approach.

Session EA: Report Release – Aspiring to Lead: Engaging K-12 Teachers as Agents of National Change in K-12 Physics Education

Location: CC - Breakout 4
Sponsor: Committee on Physics in Pre-High School Education
Co-Sponsor: Committee on Physics in High Schools
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: Rebecca Vieyra

EA01: 1:30-2 p.m. AAPT High School Teacher Camp – A New Professional Development Model

Invited – Martha Lietz, Niles West High School, 5701 Oakton St., Skokie, IL 60077; marlie@d219.org

Kelly O'Shea, LREI

In the summers of 2015 and 2016, the first and second annual AAPT High School Teacher Camps were held at locations near the summer AAPT meeting. Approximately 50 teachers from across the country met from 8 a.m. to 4 p.m. on the Sunday preceding the AAPT meeting for a day of professional development based on the "unconference" model promoted nationally by the EdCamp Foundation (edcamp.org). The camp is an organic, participant-driven professional learning experience. Due to our proximity to the AAPT meeting, we also invited two nationally known PER authors to engage us in a conversation about teaching and learning. This talk will describe the logistics for and events included in each of the two days.

https://sites.google.com/site/physicsteachercamp/home

EA02: 2-2:30 p.m. PhysTEC National Teacher of the Year: Leadership and Engagement in the Novice Years

Invited – Alexandra (Solender) Boyd, Holly Springs High School, 5329 Cass Holt Rd., Holly Springs, NC 27540; rvieyra@aapt.org

Alexandra (Solender) Boyd was recently named National PhysTEC Teacher of the Year by the Physics Teacher Education Coalition, an initiative to support physics teacher education programs, co-led by the APS and the AAPT. During this presentation, learn about Alexandra's engagement in teacher leadership as a recent PhysTEC graduate and novice teacher. Through her experiences, learn about how to encourage physics teachers in leadership starting early in their careers.

EA03: 2:30-3 p.m. Aspiring to Lead: Developing Teacher Leadership and Advocacy

Invited – Kelli Warble, Arizona State University/STEMteachersPHX/American Modeling Teachers Association, Department of Physics, Box 871504, Tempe, AZ 85287-1504; kelliw@asu.edu

Zhanna Glazenburg ,Croton-Harmon High School, New York

Jeff Milbourne, Office of Congressman Mike Honda

During this session, AAPT Physics Master Teacher Leader taskforce members Kelli Gamez Warble and Zhanna Glazenburg will present new directions for coherent and aspirational professional development and teacher leadership through the AAPT for the K-12 physics education community. Learn about the task force's vision for teacher leadership through the Teacher Leader Agency & Advocacy (TLAA) program proposal.

EA04: 3-3:30 p.m. Aspiring to Lead: Teacher Induction and Vertical Alignment

Invited – Steve Henning, PTRA, One Physics Ellipse, College Park, MD 20740; rvieyra@aapt.org

Katya Denisova, Baltimore City Schools

Fran Poodry, Vernier

Mike Mangiaracina, DC Public Schools

Trey Smith, Northwestern University

During this session, AAPT Physics Master Teacher Leader taskforce members will present new directions for coherent and aspirational professional development and teacher leadership through the AAPT for the K-12 physics education community. Learn about the taskforce's vision for teacher mentoring, induction, and K-12 vertical alignment through the TRAPP and PALs program proposals.

Session EB: PER Innovations for Reducing DFW Rates and Improving Retention in Introductory Physics Sequences

Location: CC - Breakout 5
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: Rebecca Lindell

EB01: 1:30-2 p.m. Reducing the DFW Rate by Design in Calculus-based Physics

Invited – Suzanne White Brahmia, University of Washington, Department of Physics, Seattle, WA 98195-1560; brahmia@uw.edu

This talk considers that there may be unintended bias in the culture of a typical physics course which favors the current majority by repelling the minority(1). I will describe a course designed to empower students who may feel they don't belong by: developing community, valuing naïve ideas, creating a collaborative social climate, including broad and diverse worldviews, and broadening access through scaffolded activities and targeted interventions (2). I share results from a course for mathematically underprepared engineering students, many coming from socioeconomically disadvantaged school districts, in which the curriculum and community structure has helped drive more equitable success rates in addition to significant CLASS and FCI gains.

1. Hazari and Potvin (2005) 2. Brahmia (2008)

EB02: 2-2:30 p.m. How a Simple Metacognitive Exercise Improved the Bottom Quartile 15-22%

Invited – Charles H. Atwood, University of Utah, 315 S 1400 E, Salt Lake City, UT 84112; chatwood@chem.utah.edu

Brock L. Casselman, Braden R. Ohlsen, University of Utah

To improve success rates in large general chemistry sections at the University of Utah, we realized we must improve the bottom two student quartiles performance. We implemented educational research in metacognition as well as the Dunning-Kruger effect into our homework system. In fall semester 2016 we required students in one general chemistry section to predict their scores prior to taking practice tests for each midterm exam and the final exam. Students were given feedback on topics that they did well on as well as topics where they performed poorly. They were required to make a study plan. Comparison between our treatment and control sections shows that all student quartiles improved but for the bottom quartile there was a 15-22% improvement. Using the American Chemical Society nationally normed final exam our treatment section students scored on average at the 82nd percentile (median 89th percentile) while the lowest quartile scored 53rd percentile.

EB03: 2:30-3 p.m. Parachute Courses: Reducing DFW Rates in Introductory Calculus-based Physics?

Invited – Jeff Saul, Tiliadal STEM Education, 12200 Academy Rd NE, Apt 312, Albuquerque, NM 87111-7245; jsaul@tiliadal.com

Often calculus-based physics courses have relatively high failure to pass rates (DFW rates), particularly the first course in the sequence (EP1). Often EP1 courses can inadvertently act as a filter preventing students from entering STEM degree programs of their choice. To reduce this high DFW rate and improve retention, physics faculty at a southwestern

HSI developed a parachute course. Students not doing well in EP1 can switch into this course mid-semester when it begins and the original course is dropped from their records. The course has two goals: help students maintain their GPA to keep their scholarships and help them learn skills and knowledge needed to be successful on their next attempt at EPI. Although the course was successful in helping students maintain their GPA; students retaking EP1 after the parachute course did no better than students retaking EP1 who did not take it. Reasons for this will be discussed.

EB04: 3-3:10 p.m. The Tangled Web We Weave – Interact to Not Leave!

Contributed – Justyna P. Zwolak, Florida International University, 11200 SW 8th St, Miami, FL 33199; jpzwolak@gmail.com

Eric Brewe, Drexel University and Florida International University

A major challenge for universities is to increase student persistence in continuing through a sequence of courses or the major area of study. Persistence through introductory courses is of particular importance since almost half of first-time students who leave their initial institution never come back to college. Past research indicates that a student's community and interactions likely influence whether they remain in a class/major or in school overall. Using a network analysis approach, centrality measures for the students' in-class networks were found to be fairly robust and accurate predictors of student persistence. Building on this study, we expand the proposed model to account for out-of-class collaborations, as well as the frequency of the interactions. We find that, indeed, understanding academic and social experiences of students is essential to improving retention and persistence in post-secondary introductory physics courses.

EB05: 3:10-3:20 p.m. Effect of Learning Assistants on DWF Rates and Graduation Rates

Contributed – Jessica Alzen, University of Colorado Boulder, 11061 Gray Street, Boulder, CO 80020; jessica.alzen@colorado.edu*

Valerie Otero, University of Colorado Boulder

Laurie Langdon

The Learning Assistant (LA) Model allows instructors to implement a variety of research-based instructional strategies in their classrooms. While there are some similarities across all uses of LAs, there are also many differences. This presentation focuses on the influence of the LA program on course-level DFW rates in introductory physics, chemistry, and calculus courses at the University of Colorado Boulder. We will also discuss impacts on six-year graduation. We find that the LA program has differential effects across departments and that both quantitative and qualitative investigation is necessary to understand the effectiveness of the LA Model. Possible reasons for differential effects will be discussed. We will also provide general guidelines regarding the process for conducting similar analyses, including an explanation of relevant statistical models.

*Sponsored by the Learning Assistant Alliance and Valerie Otero

EB06: 3:20-3:30 p.m. Relationship Between Stereotype Threat and Standardized Test Performance in Physics*

Contributed – Alexandru Maries, University of Cincinnati, 3405 Telford Street, Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Nafis Karim, Chandralekha Singh, University of Pittsburgh

Prior research has shown that interventions even as small as requiring a test-taker to indicate his/her gender can activate stereotype threat in situations in which there are stereotypes about performance of males and females. We have conducted an investigation in which we used various interventions described in the literature as promoting or inhibiting stereotype threat and investigated the extent to which the interventions result in changes in the test-takers' performance on a standardized conceptual physics assessment. We also identified whether students themselves endorse the predominant stereotype (that in physics males outperform females) and the extent to which these beliefs are correlated with their performance. For example, do female students who endorse the stereotype perform worse than those who do not endorse it? This along with other questions are explored in detail. *Work supported by NSF

Session EC: Innovative Models of Physics Teacher Preparation

Location: CC - Breakout 6
Sponsor: Committee on Teacher Preparation
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: Jon Stewart

EC01: 1:30-2 p.m. Flexible Pathways to Licensure for Physics and Engineering Majors

Invited – Kathleen Koenig, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; kathy.koenig@uc.edu

Helen Meyer, Eugene Rutz, University of Cincinnati

The large number of requirements necessary for earning both an undergraduate degree in physics or engineering, along with a physics teaching license, is nearly impossible for students to complete under a reasonable course load. The required courses offered across colleges is challenging for academic advisers as well. At the University of Cincinnati, these two barriers resulted in essentially no undergraduate physics or engineering majors earning a teaching license. However, by leveraging PhysTEC funding, we were able to create two more flexible pathways to high school teaching careers for these students. This presentation will showcase the two programs of study along with the conversations and administrative support that were needed to make them happen. The challenges and successes of these programs, which have been in place since 2013, will also be discussed.

EC02: 2-2:30 p.m. The Teacher Education Alliance, Mines-UNC Partnership (TEAM-UP): Evolution and Activities

Invited – Kristine E Callan, Colorado School of Mines, 1232 West Campus Rd., Golden, CO 80401; kcallan@mines.edu

Wendy K. Adams, University of Northern Colorado

To help battle the shortage of highly qualified science and math teachers, Colorado School of Mines (Mines) and University of Northern Colorado (UNC) have recently created a unique partnership that plays on each institution's strengths to produce highly-qualified STEM teachers. Mines prepares students with a strong understanding of STEM subjects, and UNC provides the coursework in education and pedagogy necessary to become a secondary science or mathematics teacher in Colorado. TEAM-UP began enrolling students in the fall semester of 2015, with additional students adding each semester. In this talk, we will describe: the evolution and structure of TEAM-UP; strategies we have employed to recruit students and improve the program; and challenges we have overcome as a collaboration.

EC03: 2:30-2:40 p.m. None Traditional Students, Training Teachers of K-12 Physics

Contributed – Duane B. Merrell, Brigham Young University, N-143 ESC, Provo, UT 84602; duane_merrell@byu.edu

We may have to look for nontraditional ways to help teachers learn physics and receive physics teacher licensure. With university prepared physics teaching students being hired before they even complete their physics teaching degrees, the need to work with other teachers to help with teaching physics is acute. Where do we make an impact in K-12 physics education that is not the students in our physics preparation programs. Who are these teachers and where and how do we encourage, support, develop their ability to teach physics.

EC04: 2:40-2:50 p.m. Teachers Teach Teachers: Physics Professional Development for Elementary In-service Teachers in an Urban District

Contributed – Katya Denisova, Baltimore City Public Schools, 200 E North

Ave., Baltimore, MD 21202; kdenisova@gmail.com

Federal emphasis on high-stakes testing in ELA and math have led elementary schools to disregard science. Elementary educators report that science, and especially physics, is the area in which they feel least prepared to teach. A disproportionate number of the students who we don't reach are students of color, students who are frequently found in underserved, urban, or rural environments with little access to high quality lab equipment, academic experiences, or discipline-specific professional development for their teachers. NSF-funded five year project SABES* (STEM Achievement in Baltimore Elementary Schools) has developed and implemented a solution to this crisis in the form of a 45 hour professional development for K-6 teachers. The course is focused on conceptual physics content and is taught by Master Teachers who receive coaching from physics pedagogical content experts. I will illustrate this work with videos from the workshops, interviews with Master Teachers and participants, and research data.

*STEM Achievement in Baltimore Elementary Schools (SABES) is supported by the National Science Foundation under Grant No. DUE-1237992

EC05: 2:50-3 p.m. Practicum-based Professional Development

Contributed – Karen E.L. King, University of Missouri, Physics 223, Columbia, MO 65211; kingkar@missouri.edu

Deborah L. Hanuscin, Delinda Van Garderen, Cathy N. Thomas, Zandra de Araujo, University of Missouri

Field experiences have long been recognized as important to preservice teacher education; however, professional development (PD) experiences for in-service teachers rarely include opportunities to practice teaching new content and using new pedagogies before returning to the classroom. The Quality Elementary Science Teaching program (QuEST), funded by an NSF DRK12 grant, embeds a week-long summer camp experience for elementary students as a 'practicum' for inservice and preservice elementary teachers. The first week of the institute puts teachers in the role of learner, as they explore new concepts using a physics curriculum designed for adult learners, and learn about the 5E learning cycle and coherent conceptual storylines. The second week provides teacher participants an opportunity to collaborate as colleagues to develop their expertise in implementing what they learned through the summer camp. Topics addressed include Magnetic Forces & Interactions, Electrical Circuits & Energy, and Properties and Structure of Matter.

EC06: 3-3:10 p.m. Using RTOP to Facilitate Student Generated and Critiqued Videos for Developing Reformed Teaching

Contributed – Kathleen Ann Falconer, University of Cologne, Gronewaldstr. 2 Cologne, NRW 50931 Germany; falconka@buffalostate.edu

Andre Bresges, Florian Genz, University of Cologne

Daniel MacIsaac, State University of New York College at Buffalo

We describe the use of pre-service and in-service teacher generated videos in physics teacher preparation and professional development programs in Cologne, Germany and Buffalo, NY. These videos are used both to learn physics content and physics pedagogy, and to promote students' self-reflection upon provided exemplar and their own physics instruction using the Reformed Teaching Observation Protocol (RTOP) rubric.

EC07: 3:10-3:20 p.m. New Instructor Training at the United States Military Academy

Contributed – Corey S. Gerving, United States Military Academy, Department of Physics & Nuclear Engineering, West Point, NY 10996; corey.gerving@usma.edu

David O. Kashinski, James E. Trimble, United States Military Academy

The United States Military Academy (USMA) is a perennial leader in rankings of its faculty. The Princeton Review rated USMA as the #1 most accessible professors. This is despite the fact that every year we rotate out one third of our junior faculty and receive inexperienced faculty in their place. Of the new instructors each year in the Department of Physics and Nuclear Engineering, the majority are active duty Army officers fresh out of a Master's degree program, and have no teaching experience of any kind. Over the course of six weeks, we transition these new instructors from military leaders to novice instructors of introductory physics. This talk will highlight the unique requirements of our faculty, and some of the techniques we use to develop the attributes expected of an instructor at USMA.

EC08: 3:20-3:30 p.m. Education Majors in Physics Classes: A Collaborative Course Design Approach

Contributed Laura Kinnaman, Morningside College, 1501 Morningside Ave., Walker Science Center, Sioux City, IA 51106; kinnamanl@morningside.edu

In the spring of 2016, Morningside College offered a new course, Investigations in Science, aimed at elementary education majors. The course was developed via conversation with the Education Department, based on their practical needs, such as Iowa state requirements, as well as objectives such as raising future elementary educators' confidence in bringing science to their own classrooms. These goals were achieved with three key features: a broad scope of content, accessible laboratory sessions, and a "teach yourself" paper. This collaborative approach to course design is applicable to the integration of any STEM field with education curricula.

Session ED: Supporting Equity through Group Work and Collaboration

Location: CC - Breakout 7
Sponsor: Committee on Diversity in Physics
Co-Sponsor: Committee on Women in Physics
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presiders: Moses Rifkin and Sam McKagan

ED01: 1:30-2 p.m. Recognizing and Addressing Unconscious Bias in Small Group Interactions*

Invited – Eleanor W. Close, Texas State University, Dpt. of Physics, 601 University Dr., San Marcos, TX 78666-4615; eclose@txstate.edu

Reformed instructional practices often engage students in working with each other, in pairs or small groups, on difficult conceptual questions or problem-solving activities. Many research studies have found interactive-engagement instruction to lead to greater learning gains than more teacher-centered methods. However, small group collaborations also leave room for students to enact unconscious bias in their interactions with each other, creating or reinforcing barriers to participation for students from groups already under-represented in the physics community (e.g., women). How do we promote equity in these instructional contexts? Using short video episodes of group work interactions in real classrooms from the Periscope project, I will analyze dynamics around equity in specific student interactions, and make instructional suggestions.

*Supported by NSF DUE-1557405, NSF DUE-1431578, and the Halliburton Foundation

ED02: 2-2:30 p.m. Being "Smart" in Science Class

Invited – Kelly O'Shea, Little Red School House & Elisabeth Irwin High School, 40 Charlton Street, New York, NY 10014; kellyoshea@gmail.com

Working in groups helps establish that science is something that humans do together. In my usual day-to-day routine of class, students work "individually-together" at tables and then draw on whiteboards to share and discuss solutions with other groups and come to a consensus on each problem. Through this small and large group work, I try to disrupt status hierarchies and create opportunities for students to see value in a variety of ways to "be smart" in science class. I also try to provide multiple entry points for students to access the content and skills. In this talk, I will share that work and the questions that I am trying to figure out and address in my high school classroom.

ED03: 2:30-3 p.m. Creating a Classroom Ethos of "Learning Together": Strategies & Equity Implications

Invited – Gina Quan, University of Maryland, 082 Regents Drive, College Park, MD 20740; gina.m.quan@gmail.com

Angela Little Michigan State University and the University of Maryland

The Compass Project (past and present) University of California, Berkeley

This talk will discuss classroom structures and norms implemented by member programs of the Access Network, a research-practice community of several undergraduate STEM equity-focused programs. We draw from our experiences as former student-leaders in one member program, the Compass Project. A central goal of the Compass classroom was to disrupt common ways of "knowing" and being "good at" physics (e.g. gaining status through use of jargon terms). Instead, we worked toward a classroom community that had an ethos of "learning together," where all students could meaningfully engage in collaboratively building physics knowledge. This talk will discuss how this goal was embodied within classroom activity structures. The ideation, implementation, and refinement of these strategies are the collective effort of many past and current members of the Compass Project and Access Network community, and continue to have life beyond our own membership in the Compass Project.

ED04: 3-3:30 p.m. CU Prime Diversity Workshop Model: Training Teachers and Student Leaders Around Issues of Equity

Invited – Simone Hyater-Adams, University of Colorado Boulder, 390 UCB, Boulder, CO 80309; simone.hyateradams@colorado.edu

Dimitri R Dounas-Frazer, Katherine Rainey, University of Colorado Boulder

Daniel Reinholtz, San Diego State University

Self-education is an invaluable tool that can push physics educators forward in their effort to create inclusive classrooms. This work highlights the CU Prime Diversity Workshops as a model for doing so. CU-Prime, a student run organization at CU Boulder, runs a course for first-year undergraduates and holds diversity workshops for the organizing group in order to provide space and time to reflect on and grapple with difficult issues around diversity and inclusion. With a structure based on readings, informal videos, reflection, and discussion these workshops serve as a space of self-education for instructors of the course as well as other members of the leadership. This talk will overview the structure and framing of our most successful workshops, highlighting the benefits and pitfalls of their structure, as well as the implications of these workshops on the course that the group designs and teaches.

Session EE: Improving Student Learning With the Use of Popular Media

Location: CC - Breakout 8
Sponsor: Committee on Space Science and Astronomy
Co-Sponsor: Committee on Science Education for the Public
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: *Kristi Concannon*

EE01: 1:30-2 p.m. The Best Physics Examples from Superheroes and Science Fiction

Invited – Rhett Allain, Southeastern Louisiana University, SLU 10878, Hammond, LA 70402; rhettallain@gmail.com

There are countless movies that focus on superheroes or science fiction and these can be quite popular. Although we all understand that they contain fictional events, this doesn't stop us from using physics to analyze different situations. In this talk, I will take examples from my favorite movies and present interesting physics models to address important questions from both Star Wars and Marvel movies.

EE02: 2-2:30 p.m. Open the Door with Superheroes and Bits of Science Fiction

Invited – Richard Gelderman, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu

References to popular media are an incredibly important way to capture a moment of attention from this generation of students constantly watching screens and blocked away from the world by earbuds/headphones. Marvel and DC comics have been consistently dominating the cinematic box office, so using references from these movies is a way to connect your lessons to these students' interests. Technological innovations make it easy to share clips within the protection of copyright law. Mechanics, E&M, thermodynamics, waves, optics, and physics of atoms are all available ready to be tapped for helping learning. Just-in-time lessons, and student centered group activities are excellent platforms for working with these topics.

EE03: 2:30-3 p.m. Practical Strategies to Use Popular Media in Your Teaching Effectively

Invited – Timothy F. Slater, University of Wyoming 1000 E University (MC 3374) Laramie, WY 82071; timslaterwyo@gmail.com

Popular media has never before been more frequently accessed by students. For many, mobile cell phones, tablets, computers, and Internet-linked smart televisions makes access a nearly daily activity. As a result, students naturally expect video and popular media to be a part of the contemporary learning experience. At the same time, discipline-based science education research clearly shows that it is irresponsible simply to turn to popular media as a classroom babysitter and hope that learner will gain something transformative from the experience. Instead, media needs to have a clearly specified and explicitly specific purpose that is explained to students. One approach to highly structure the learning experience is to pose three different styles of questions: 4-8 factual questions (How far away from Earth is Hubble?); 2-4 synthesis & evaluation questions (Which observations were most scientifically useful?); and 1-2 self-reflection questions (Which 12 HST images would you pick for a calendar & why?).

EE04: 3-3:10 p.m. Current Space and Astronomy Events which Help Teach Physics

Contributed – John P. Cise, Austin Community College, 1212 Rio Grande St., Austin, TX 78701; jpcise@aol.com

Current Space and Astronomy events have excellent fundamental physics applications at their core. For 10 years I have been using current physics-based events to help teach physics. About 1000 current event applications exist in my file. I use these recent physics based events for: Introduction to physics concepts, Quiz and test questions, make up quizzes, extra credit. I will present a few current (2015 – 2017) Space and Astronomy events that help teach introductory physics.

EE05: 3:10-3:20 p.m. Promoting Phun in Conceptual Physics: Physics in Movies and Everywhere

Contributed – DJ Wagner, Grove City College, 100 Campus Drive, Grove City, PA 16127; djwagner@gcc.edu

In the spring of 2013, our department re-evaluated the one-semester survey conceptual physics course we offer as part of our core curriculum. Based on feedback from students in the course, we added a very successful "Physics of Movies" component starting in fall, 2013. I also add a discussion board, "There's Physics in That" in the fall offerings, in which students post on where they have seen physics outside of the classroom and commented on classmates' posts. Many students fully embrace the spirit of this activity, and excellent on-line discussions have taken place. This talk will summarize my efforts in the class and describe the results of assessment.

EE06: 3:20-3:30 p.m. Exploring Impacts of Popular Culture References within Physics Teacher Education

Contributed – Richard P. Hechter, University of Manitoba, Department of Curriculum, Teaching, and Learning, Education building, room 227B, Winnipeg, MB R3T2N2 Canada; richard.hechter@umanitoba.ca

Do you integrate varying popular media sources and popular culture references as the context for experiential, inquiry-based advanced learning in pre-service physics teacher education classes? If so, that's awesome! If you do not, have you ever wanted to but was not sure how to do it? Perhaps you have wondered if using these unique references makes a substantive difference in terms of student learning? If your answer is yes to any of these questions, join me as I share examples of how and why I use this approach in my classes, and the insights gained through a mixed-methods study designed to evaluate the impact of this approach on pre-service teacher learning and pedagogical knowledge development.

Session EF: The Use of IOLab for Introductory Laboratory Reform

Location: CC - Ballroom D
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Educational Technologies
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: Mats Selen

EF01: 1:30-3:30 p.m. Measuring Moments of Inertia with the IOLab Device

Invited – Scott Dudley, TASIS England, Coldharbour Lane, Thorpe, Surrey TW20 8TE United Kingdom; sdudley@tasisengland.org

Scott C. Dudley, Colton K. Dudley, Francesco Insulla, TASIS England

Here we show how to measure the moment of inertia of inexpensive common objects using an IOLab device. Estimates of the error in the technique, a comparison with video analysis, and analysis of the most suitable masses and dimensions for accuracy given the range of the IOLab's force probe are also presented.

EF02: 1:30-3:30 p.m. Open-ended Circuit Labs with the IOLab

Invited – Louis Leblond, Penn State University, 234 Davey Lab, University Park, PA 16802; lul29@psu.edu

We have recently redesigned almost all calculus-based mechanics and E&M introductory labs to use the IOLab device when possible and to follow a more open-ended approach heavily influenced by the Investigative Science Learning Environment (ISLE). In most labs, the students were asked to investigate questions by formulating hypothesis and testing them by designing an experimental setup. They would then select lab equipment and measuring tools from the sets available to perform the experiment. Among the tools and equipment available we had the IOLab device which provide a "all-in-one" portable measurement tool. This device allowed us to do the lab in any classroom using student's laptops. Here we report on the series of circuit lab used in E&M and how they compared to previous labs which were more cookbook in style and which were using PASCO equipment. We outline some key differences of doing circuit labs with the IOLab and where extra equipment, such as multimeters, where needed.

EF03: 1:30-3:30 p.m. Research Validated Distance Learning Labs for Introductory Physics Using IOLab

Invited – David Sokoloff, University of Oregon and Portland State University, Department of Physics, University of Oregon, Eugene, OR 97403; sokoloff@uoregon.edu

Erik Bodegom, Portland State University

Erik Jensen, Chemeketa Community College

The IOLab is a versatile, relatively inexpensive data acquisition device developed by Mats Selen and his colleagues at University of Illinois.[1,2] It is self-contained in a cart that can roll on its own wheels, while an optical encoder measures motion quantities. It also contains sensors to measure a variety of other physical quantities like force, temperature, light intensity, sound intensity and current and voltage. With a current cost of around $100, students can purchase their own individual device (like a clicker), and can—in theory—use it to do hands-on laboratory, pre-lecture (flipped classroom) and homework activities at home. We report on the preliminary results of a project to develop distance-learning (DL) laboratories using the IOLab. We have developed RealTime Physics[3,4]-like mechanics labs based on the IOLab, and tested them in supervised laboratory environments and in distance learning mode at Portland State University and Chemeketa Community College. We will describe the labs and lab environments, and present preliminary research on student learning using the FMCE.[5]

(1) See http://www.iolab.science/ (2) Funded under U.S. National Science Foundation grant DUE – 1505086, July 1, 2015-June 30, 2017. (3) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, "RealTime Physics: Active Learning Labs Transforming the Introductory Laboratory," Eur. J. of Phys.: 28 (2007), S83-S94. (4) David R. Sokoloff, Ronald K. Thornton and Priscilla W. Laws, RealTime Physics: Active Learning Laboratories, Module 1: Mechanics, 3rd Edition (Hoboken, NJ, John Wiley and Sons, 2011). (5) Ronald K. Thornton and David R. Sokoloff, "Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula", Am. J. Phys.: 66, 338-352 (1998).

EF04: 1:30-3:30 p.m. Interference-Diffraction with the IOLAB

Poster – Stephen J. Mecca, Providence College, 1 Cunningham Square, Providence, RI 02908; smecca@providence.edu

Seth Ashman, Liam Reilly, Providence College

So many of the lessons of a traditional General Physics lab can be accomplished with experiments designed around the IOLAB. Yet some experiments, such as E-field mapping and physical optics, remain elusive challenges for the IOLAB. This station will demonstrate the use of the IOLAB for a simple interference/diffraction experiment of the type often carried out in a traditional General Physics lab. The lab is one of many being planned for a pilot project, known as Lab Without a Lab (LWL).

EF05: 1:30-3:30 p.m. Investigating Impulse and Momentum with the IOLab

Poster – Shawn A. Weatherford, University of Florida, P.O. Box 118440, Gainesville, FL 32611-9500; sweatherford@ufl.edu

Robert DeSerio, University of Florida

Students enrolled in the University of Florida Online program complete a 100% online version of the first semester algebra-based introductory physics course incorporating hands-on remote data collection and analysis labs using the iOLab cart and software. Six of the 10 labs designed for this lab course utilize the data acquisition capabilities of the iOLab cart. This poster station demonstrates one of these lab activities, an investigation of the Impulse and Momentum Principle. Students connect different attachments to the onboard force sensor to collect data for impact forces while the embedded wheel sensor collects data for the cart's dynamics. Additionally, the poster will analyze student responses to questions posed using the iOLab software's built-in lesson player and the asynchronous conversations within student groups using the course LMS.

EF06: 1:30-3:30 p.m. Investigating the Buoyant Force and Density Using the IOLab Device

Poster – Eric Mandell, Bowling Green State University, 104 Overman Hall, Toledo, OH 43614-5338; meric@bgsu.edu

Through the use of the IOLab Device, students are able to measure the weight of an object in air and the apparent weight of the same object, when immersed in another fluid. This allows for the determination of the buoyant force on the object, when submerged in the other fluid, as well as the object's volume and average density. Students are able to quickly apply this technique to discover the volume and average density of any object, and even use their results to determine the density of an unknown fluid. Through these investigations, students achieve a better understanding of the properties that lead to an object floating or sinking within a fluid, are better able to reflect on other class activities involving the buoyant force, and have worked with a procedure that can determine the volume and average density of any object.

EF07: 1:30-3:30 p.m. IOLab as a Versatile Platform for Prototype Development

Poster – Yuan Yuan, Fudan University, No. 220 Handan Road, Dept. Phys., Shanghai, Shanghai 200433 China; yuanyuan@fudan.edu.cn

Min Ji, Yanyan Wen, Gan Qing,Yongkang Le, Fudan University

Under strain, biomaterials exhibits viscoelasticity: at constant strain, the extension changes with time. Approaches developed for the measurement of Young's modulus are no more applicable for the characterization of such behavior. Equipped with a variety of sensors for most quantities interested in physics lab courses, IOLab turns to be a versatile platform for prototype development. Here we report on the development of a teaching lab appropriate for the demonstration, as well as quantitative measurement, of the viscoelasticity in biomaterials, taking hair as the sample.

EF08: 1:30-3:30 p.m. IOLab Investigations Beyond Mechanics: Equipotential Lines & Lung Function Tests

Poster – Abhilash Nair, Michigan State University, 5510 Timberlane St. Apt D2, East Lansing, MI 48823; nairabhi@msu.edu

Vashti Sawtelle, Michigan State University

We present two IOLab investigations that utilize the expansion header pins to take advantage of the IOLab's analog output and input. In one investigation, we demonstrate how two IOLab devices can be used as a battery and a voltmeter to conduct an investigation of equipotential lines. We show how an equipotential lines lab can be done inexpensively with non-technical off-the-shelf parts you would find in everyday-life. A second investigation uses a simple spirometer design to enable the IOLab to function as a biomedical device and conduct lung function tests. Many life-science students in the physics classroom have an interest in health professions, this activity builds on that interest by providing students an opportunity to interface with biomedical technology. We discuss how devices like the IOLab combined with simple designs can increase access to exciting and complex physics investigations.

EF09: 1:30-3:30 p.m. Kirchoff's Laws Using IOLab*

Poster – Anthony Bassante, Stony Brook University, 100 Nichols Road, Stony Brook, NY 11794-3800; anthony.bassante@stonybrook.edu

Nicole Cronin, Thomas K. Hemmick, Aneta Iordanova, Chris Zangler-Scaduto, Stony Brook University

Stony Brook University uses IOLab devices to provide an "online" or "at home" physics laboratory experience. This lab station will demonstrate the Kirchoff's Laws lab that we developed. Students use a "kit" of small parts enabling the full suite of labs to be performed. For this lab, they require a small breadboard, hookup wire, a battery pack holding 3 AAA cells, and precision resistors including 4.7 kOhm, 10 kOhm, and 1 Ohm. The IOLab serves as a source of ~3.3 Volts and the battery pack as ~4.5 Volts. The circuit is wired once, placing 1 Ohm resistors in each leg where a current measurement is required. The "High Gain" input measures a differential voltage across 1 Ohm in the range +/- 1 mV (interpreted as +/- 1 mA). Current direction and value measurements are taken in pairs (reversing the leads) compensating for any offsets.

*This work was supported by the S-BOLD (Stony Brook OnLine Development) initiative.

EF12: 1:30-3:30 p.m. The IOLab and Magnetic Field – Magnetic North Versus Actual Direction

Poster – Trevor S. Volkwyn, Uppsala University, Lägerhyddsvägen 1, Uppsala, 752 37 Sweden; trevor.volkwyn@physics.uu.se*

John Airey, Stockholm University and Uppsala University

Bor Gregorcic, Filip Heijkenskjöld, Cedric Linder, Uppsala University

Most students will be familiar with the compass as a tool that points north. However, the compass only shows us one component—the terrestrial projection—of the Earth's magnetic field. In contrast, the IOLab potentially gives students access to the actual direction of the field. We have designed an open-ended task in which pairs of students use the IOLab to determine the actual direction of the Earth's magnetic field in a laboratory classroom. Without any prior instruction or step-by-step procedure to follow, students simultaneously coordinate a set of resources: speech (in groups; and with facilitator), interpretation of graphical readouts, physical manipulation of the IOLab and proprioception. By coordinating the resources available, the students in our study can be seen to quickly come to a moment of disciplinary insight, where they realize the true direction of the magnetic field.

*Sponsored by Cedric Linder

EF14: 1:30-3:30 p.m. Using Resonance to Measure the Speed of Sound with IOLab*

Poster – Thomas K. Hemmick, Stony Brook University, 100 Nichols Road, Stony Brook, NY 11794-3800; Thomas.Hemmick@stonybrook.edu

Anthony Bassante, Nicole Cronin, Aneta Iordanova, Chris Zangler-Scaduto, Stony Brook University

Stony Brook University uses IOLab devices to provide an "online" or "at home" physics laboratory experience. During the 2016 academic year, we taught a pilot class with 20 experiments. Starting in summer 2017, we will offer the IOLab based alternative to all SBU students. This lab station will demonstrate the speed of sound lab that we developed using a single IOLab device. The lab is simple. Students create a short tube using household materials (e.g. rolled up paper) and place the tube next to the IOLab microphone input. At the far end of the tube, they insert "ear buds" driven by their computer. A "tone generator" web site creates a frequency ramp that the students record. The data exhibits multiple maxima, the frequencies of which yield not only the tube's fundamental, but coupled with the tube's length produce an accurate measurement of the speed of sound.

*This work was supported by the S-BOLD (Stony Brook OnLine Development) Initiative.

EF15: 1:30-3:30 p.m. An Online Lab Section with IOLab and Remotely Operated Experiments

Poster – Takashi Sato Kwantlen, Polytechnic University, Kwantlen Polytechnic University, 12666 72nd Ave., Surrey, BC V3W 2M8; Canada takashi.sato@kpu.ca

Jillian Lang Kwantlen, Polytechnic University

We report on a pilot offering of an online lab section of PHYS 1100, a one-semester preparatory level, algebra-based course with separate classroom and lab components at Kwantlen Polytechnic University, Canada. During the winter 2017 semester, one lab section was designated "online," which students took in conjunction with a regular, on-campus class. The lab activities consist of seven experiments based on the IOLab and two experiments that are remotely operated through the internet, using the RWSL facility in partnership with North Island College. Topics parallel those in the on-campus labs. Each lab is preceded by a pre-lab assignment designed to equip students with theory, orientation, and analysis tools required for the experiment. Student lab reports are heavily guided early in the semester but become progressively freer in format, with a corresponding progression in student expectations. Student outcomes and lessons learned for continued implementation will be discussed.

EF16: 1:30-3:30 p.m. An Online Standing Wave Lab Using the iOLab Device

Poster – Nicole Cronin, SUNY Stony Brook, 100 Nicolls Road, Stony Brook, NY 11794; nicole.cronin@stonybrook.edu

Thomas Hemmick, SUNY Stony Brook

Anthony Bassante, Aneta Iordanova, Christopher Zangler-Scaduto, SUNY Stony Brook

At Stony Brook University, there has been an increased push in the development of online courses. For the past three years, the introductory physics lecture course has been successfully implemented online, but students are still required to physically be on campus for labs. With the help of the iOLab device developed at the University of Illinois, there is an effort to change this. A total of 20 labs were produced for both semesters of the two-course lab sequence, with a total of eight being unique to Stony Brook. A pilot class, with 30-40 students, was held for both lab courses, and was assessed through student surveys, focus groups and lab quizzes. Here, we specifically report on a standing wave lab using the iOLab device, motors, strings, and battery packs. By changing the tension in the string, students can change the number of nodes of the standing wave pattern. By reading out the tension in the string using the force probe for at least three different harmonics, students can find the frequency at which the motor vibrates. They can also use the Fast Fourier Transform function to find this frequency, which will enable the students to compare the two values. This lab not only enables students to better picture standing wave patterns, but it allows them to utilize and manipulate many equations pertaining to waves on a string and specifically standing waves.

EF17: 1:30-3:30 p.m. Benchmarking IOLab Against Other Sensors

Poster – Ian Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark; bearden@nbi.dk

Kristian á Brúnni, Alexander Tøt, Niels Bohr Institute

As part of an undergraduate research project, a group of our students (co-authors on this poster) have compared the IOLab to other sensors on the market. The comparisons include not only subjective measures such as perceived ease of use, but also detailed comparisons of resolutions and dynamic ranges of the various on board sensors. We will present the results of this project as well as demonstrate some of the testing procedures.

EF18: 1:30-3:30 p.m. Investigating Fluids with the IOLab

Poster – Rebecca Lindell, 820 South 12th Street, Lafayette, IN 47905; rlindell@tiliadal.com

James P. Vesenka

The wide range of sensors available on IOLab avail themselves to numerous fluid statics and dynamics guided-inquiry investigations. These activities are specifically catered to the large introductory physics for the life sciences (IPLS) audience. A suite of fluids activities has been designed for face-to-face as well as online/remote instruction that includes an inexpensive kit and common household items to supplement the IOLab data collection abilities. The guided inquiry approach is based on modeling instruction in which students investigate dependencies between measureable quantities such as force, pressure, position, and time in order to develop foundational fluids principles. Activities include the investigation of buoyancy, basic definition of pressure, ideal gas laws, hydrostatic and dynamic pressure.

EF19: 1:30-3:30 p.m. Rocking and Rolling the IOLab with an Easy Modification

Poster – Katherine Ansell, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, IL 61801; crimmin1@illinois.edu

Mats Selen, University of Illinois at Urbana-Champaign

The IOLab device naturally lends itself to the study of many different topics in mechanics, but it is difficult to devise ways to use it to study rotational dynamics. By a fortunate coincidence, we have found an easy and inexpensive method to modify the device so it can roll about its y axis. In this session, we will show our modified IOLab setup and present a rotational dynamics experiment that we have used in our introductory laboratory classroom. We will also highlight interesting ways students can investigate the physics of this experimental system.

EF20: 1:30-3:30 p.m. LRC Circuit Resonance Inspected with the IOlab

Poster – Christopher T. Zangler-Scaduto Stony Brook University, 7 Bancroft Street, East Setauket, NY 11733; chrisznglrscdto@gmail.com

Thomas K. Hemmick , Nicole Cronin, Anthony Bassante, Aneta Iordanova, Stony Brook University

In this lab students drive a LRC circuit using a ramp frequency provided by a website and a pair of earbuds. The students construct multiple LC combinations (Series, Parallel, etc) to produce multiple resonant frequencies. The final plot is an expected frequency vs. measured frequency. Students are guided through this process by instructional videos embedded in the IOLab interface. Students build the described circuit on their breadboard and measure the voltage as the frequency changes.

EF21: 1:30-3:30 p.m. LRC Resonance Measured Using IOLab*

Poster – Chris Zangler-Scaduto, Stony Brook University, 100 Nichols Road, Stony Brook, NY 11794-3800; chrisznglrscdto@gmail.com

Anthony Bassante, Nicole Cronin, Thomas K. Hemmick, Aneta Iordanova, Stony Brook University

Stony Brook University uses IOLab devices to provide an “online” or “at home” physics laboratory experience. This lab station will demonstrate the LRC Circuit lab that we developed. The digitization rate of the IOLab voltage input (100 Hz) is a bit slow for an AC lab, but the microphone input is not (4800 Hz). Using a 3.5mm jack extension cord and breadboard-compatible jacks, students intercept the audio output of their computer on a breadboard. Introducing LC in series with their ear buds makes a resonant RLC circuit with the ear buds taking the role of R. The circuit is driven by a frequency ramp defined by a web-based “tone generator”. Students to measure the resonant frequency for several choices of C, verifying not only the resonant condition, but also the formula for series and parallel equivalent capacitances.

*This work is supported by the S-BOLD (Stony Brook OnLine Development) Initiative.

Session EG: Panel – Highlights of TYC New Faculty Experience

Location: Marriott - Covington Ballroom I
Sponsor: Committee on Physics in Two-Year Colleges
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: Todd Leif

The New Faculty Experience for Two-Year College faculty is an 18-month immersion and mentoring program offered to faculty in their first five years of teaching full-time at a two-year college in the United States funded by NSF grant # 1225603. This is the commencement of the fourth cohort of faculty to go through the experience. The presentation will consist of an overview of the 18-month experience, some statistical data on the participants, and the impact the project is making. It also includes a group of participants who will share their experiences from the conference.

EG01: 1:30-3:30 p.m. Introduction to the Two-Year College New Faculty Experience

Panel – Scott Schultz, Delta College, 1961 Delta Rd, F-217, University Center, MI 48710; sfschult@delta.edu

The New Faculty Experience for Two-Year College Physics Faculty is a comprehensive program to improve student learning through faculty professional development. The 18-month experience uses both online and face-to-face sessions to encourage and support faculty in their first five years of full-time instruction to transform their pedagogical approach to use research-based active engagement strategies. This is the fourth cohort to complete the program. A complimentary program is the Alumni-in-Residence program where several past participants return to help lead sessions and to engage in leadership development. The program has been very successful over the last decade in impacting new physics faculty to improve classroom learning, but through retirements, the ranks of two-year college physics leaders were being depleted. We created a program to support the professional development to build the next generation of leaders for the community.

Session EH: Results of a Comprehensive National Survey of the Uses of Computation in Undergraduate Physics Programs

Location: CC - Breakout 9
Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: Kelly Roos

EH01: 1:30-2 p.m. Background and Design of the National Survey*

Invited – Norman Chonacky, Yale University, 36 Lincoln St., New Haven, CT 06511; norman.chonacky@yale.edu

Marcos Caballero, Michigan State University

Robert Hilborn, American Association of Physics Teachers

Laura Merner, American Institute of Physics

Over 15 years ago we first learned of impacts on preparation of undergraduate physics majors due to lack of computation in courses. The vehicle was an AIP report based on its employment survey of recent physics BS graduates.[1] Subsequent research endeavored to evaluate actual usage of computation in courses and underlying factors.[2,3] In 2014 NSF-IUSE funding finally permitted creation of a comprehensive survey of undergraduate computation usage in a stratified random sample of physics department types and their faculty. The design of this survey included consultation with a focus group of diverse stakeholders and involved a coalition of research entities—the AAPT, the AIP, and two universities. My talk focuses on the project's conception and the design of its questionnaire. Others will disclose some details of its results and their relevance to efforts to promote integration of computation across physics curricula.

* Partial support for this project was provided by the NSF through IUSE-1432363.

1. Ivie, R. and K. Stowe (2002). AIP Pub. Number R-433, "The Early Careers of Physics Bachelors" 2. Fuller, R. G. (2006). "Numerical computations in U.S. undergraduate physics courses." Comput. in Sci. & Eng 8(5): 16-21. 3. Chonacky, N. and D. Winch (2008). "Integrating computation into the undergraduate curriculum: A vision and guidelines for future development." American Journal of Physics 76(4&5): 327-333.

EH02: 2-2:30 p.m. National Assessment of Computational Instruction in Undergraduate Physics Departments

Invited – Laura Merner, American Institute of Physics, 1 Physics Ellipse Drive, SRC, College Park, MD 20740; lmerner@aip.org

This presentation discusses results from three national surveys of physics faculty that assess the current state and possible future of computational instruction in undergraduate physics departments in the U.S. The survey collected quantitative evidence about the state and nature of computational instruction in undergraduate physics departments. Results will be presented on five main areas: Structure of and support for computation in the undergraduate physics curriculum, barriers, and successes to teaching computation, the perceived value of computational physics by faulty members, the future of computation in physics classrooms, and experiences of faculty member.

EH03: 2:30-3 p.m. Characteristics of Departments and Faculty that Teach Computation

Invited – Marcos Caballero, Michigan State University, 567 Wilson Rd., Room 1310A, East Lansing, MI 48824-2320 caballero@pa.msu.edu

Laura Merner, American Institute of Physics

Norman J. Chonacky, Yale University

Robert C. Hilborn, American Association of Physics Teachers

Computation is a central aspect of 21st century physics practice; it is used to model complicated systems, to simulate impossible experiments, and to analyze mountains of data. Physics departments and their faculty are increasingly recognizing the importance of teaching computation to their students. We recently completed a national survey of faculty in physics departments to understand the state of computational instruction and the factors that underlie that instruction. We will present the instructional practices that faculty in surveyed departments are using to teach computation and offer descriptive characteristics that typify these different types of instruction.

EH04: 3-3:30 p.m. Survey Results Viewed Through the AAPT Recommendations for Computational Physics

Invited – Ernest Behringer, Eastern Michigan University, Dept Physics and Astronomy, 303 Strong Hall, Ypsilanti, MI 48197; United States ebehringe@emich.edu

Because computation is ubiquitous in the practice of physics, the AAPT issued a statement on computational physics in 2011 urging "every physics and astronomy department [to] provide its majors and potential majors with appropriate instruction in computational physics." The AAPT Undergraduate Curriculum Task Force (UCTF) was established in January 2013 and developed a set of recommendations, approved in 2016, for including computational physics skills and practices in the undergraduate physics curriculum. The survey and associated results described in the preceding talks will be viewed through the lens of the AAPT recommendations to identify productive paths forward for instructors, students, and developers.

Session EI: High School

Location: CC - Breakout 10
Sponsor: AAPT
Date: Tuesday, July 25
Time: 1:30–3:20 p.m.

Presider: TBA

EI01: 1:30-1:40 p.m. Lessons from an Online Course Preparing Students for AP Physics 1

Contributed – Andrew G. Duffy, Boston University, 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu

For the past three years, Boston University has offered an online course on edX to help prepare students for the AP Physics 1 exam in May. In this talk, I will discuss our experiences, comment on the AP Physics 1 exam results, and lay out future plans.

EI02: 1:40-1:50 p.m. Using Ranking Tasks, TIPERS and nTIPERS in HS Physics

Contributed – Kathleen L. Willard, Monessen City School District, 20 Jackson Drive, Monessen, PA 15062; kwillard@wiu.k12.pa.us

Physics Education Research has put out several books that can be used to facilitate student learning. I will talk about how I use these in the classroom to get a snapshot of student understanding while helping them transition their thinking from their other classes to their physics class.

EI03: 1:50-2 p.m. Assessing Modeling Instruction's Impact on Representational Use in Lab Situations

Contributed – Kathleen A. Harper, The Ohio State University, 244 Hitchcock Hall, 2070 Neil Ave., Columbus, OH 43210; harper.217@osu.edu

Lin Ding, School of Teaching & Learning; The Ohio State University

Ted M. Clark, Dept. of Chemistry & Biochemistry; The Ohio State University

Matthew Kennedy Fuchs, Mizrachi School

Workshops in Modeling Instruction for physics have been offered in central Ohio for 14 years. Their evaluation has largely focused on changes in the conceptual understanding of the participating teachers, as well as of their students, using the Force Concept Inventory. Previously, we reported on using a "lab question" from a recent AP exam as a way of determining the impact of the workshop on the participating teachers. It was found that the workshop influenced the teachers' responses, particularly that they employed representational skills gained in the workshop. In this continuation study, the same question was given to students taking AP physics from Modeling teachers. These teachers varied in the number of years since they took the workshop, as well as the degree to which they employed Modeling techniques. The analysis and results will be discussed.

EI05: 2:10-2:20 p.m. Developing Literacy in the 9th Grade Physics Classroom

Contributed – Austin Hauser, Herron High School, 1221 Winter Hawk Ct., Greenwood, IN 46143; austinchauser@gmail.com

Rachelle Klinger, Herron High School

The development of literacy skills are often lost in the physics curriculum. At Herron High School, a public charter high school in Indianapolis, physics is taught as a first science course. Because of these two factors, we have gradually introduced literacy as an emphasis in our skills-based curriculum. We have developed materials, content, and instructional methods through close cooperation with our English and Social Studies departments. We will share our successes, challenges, and future goals for science literacy in physics.

EI06: 2:20-2:30 p.m. The New CPEP History and Fate of the Universe Chart

Contributed – Katrina Brown, University of Pittsburgh at Greensburg, 150 Finoli Drive, Greensburg, PA 15601; kwb@pitt.edu

The Contemporary Physics Education Project (CPEP) has revised its History and Fate of the Universe chart. The chart helps students find some answers to the questions we have about where we've been and where we're going. We discuss how this chart can be used not only to bring interest to the classroom but also how it can be used to teach elements of cosmology. The chart is complemented by The Universe Adventure which is online and accessible in several languages. We will show the original and updated versions of the chart, and introduce teaching activities that can be used to accompany it.

EI07: 2:30-2:40 p.m. Teaching Vector Mathematics with a Three Wheeled Robot

Contributed – James H. Lupton, Greenhills School, 850 Greenhills Drive, Ann Arbor, MI 48105; jlupton@greenhillsschool.org

Damian Khan Greenhills School

We have built and tested a three-wheel robot with independent drives in order to facilitate teaching vector concepts. Students will use a robot driven by three servo motors with wheels which provide push only the corners of an equilateral triangle. They will be required to discover how to drive the vehicle in the horizontal x-y plane. The vector transformation matrix reinforces algebraic concepts at a critical time in the physics students learning. The lesson will be tested with High School Honors and Calculus based Physics classes in the fall of 2017. The goal is to facilitate student understanding of orthogonal vector components and give them practice in performing vector transformations.

EI08: 2:40-2:50 p.m. High Altitude Ballooning in Two Days

Contributed – Eric Strong, School for the Talented and Gifted, 1201 E. 8th Street, Suite 302, Dallas, TX 75203; ericstrong8911@gmail.com

The School for the Talented and Gifted High School (TAG), Dallas ISD, has embarked on a "TAG to the Stratosphere" flight test program to develop the processes and technology to carry an instrumented payload to an altitude of 125,000 feet. For each flight, a student team spent one school day to design and build the payload and associated hardware and a second day to launch, track, chase, and recover. The first two flights of the program have been completed. With the first flight of the program focused on a proof-of-concept goal and the second flight of the program focused on a subsystem testing, a well-developed knowledge base is available for subsequent flights. This knowledge base includes flight path prediction, camera (still and video) selection and reprogramming, payload suspension methods, radar reflector construction, GPS data recording, recovery location determination, balloon inflation procedures, balloon chase procedures, and FAA regulations.

EI09: 2:50-3 p.m. Modeling with Chinese Students

Contributed – Igor V. Proleiko, Jiangsu Tianyi AP Center, 18 Erquan, Wuxi, Jiangsu 214000 China; igor.proleiko@yandex.ru

While Chinese students are famous for their dedication to studying and responsibility, Modeling instruction is not a familiar way of learning for them. Challenges and accomplishment with the students in AP Physics are discussed and analyzed.

EI10: 3-3:10 p.m. Using Escape Rooms to Assess Physics Skills

Contributed – Megan McEwen, Chadwick School, 26800 South Academy Dr., Palos Verdes Peninsula, CA 90274; United States mmcewen@chadwickschool.org

Using play in the classroom can help increase student engagement, inspire more creative thinking and problem solving strategies, and make the assessments and class periods more enjoyable for everyone. I have used Escape Rooms especially, with multi-day Escape Rooms becoming my final exams, for the last four years with great results, which I will share in the course of this paper.

EI11: 3:10-3:20 p.m. Lise Meitner and Nuclear Fission: Gender, Trajectory, and Nobel in Physics Classrooms

Contributed Isabelle Priscila Carneiro Lima, Federal University of Bahia, Av. Cardeal da Silva, 213. Edifício Trianon - Apto 37. Salvador, BA 40231305 Brazil; isapris@gmail.com

Maria Cristina Martins Penido Lise Meitner and Nuclear Fission: gender, trajectory, and Nobel in physics classrooms

The aim of this paper is to present a didactic strategy used in a high school classroom in order to address ideas present in the Nuclear Fission theory in a historical perspective focusing on the role of Lise Meitner in the development of this theory. With this strategy, we intended students to know her contributions, from studying her published articles and aspects of her academic trajectory. This way, we attempted to promote a discussion about peculiar characteristics to a woman's trajectory in the academy and the reasons for her absence among Nobel Prize winners. At the end of the intervention, it was possible to see, through the discussions, that the students identified aspects that characterize the development of science, such as unequal opportunities experienced by women at that time, and their relation to the development of a theory.

Session EJ: Labs/Apparatus

Location: Marriott - Covington Ballroom III
Sponsor: AAPT
Date: Tuesday, July 25
Time: 1:30–2:30 p.m.

Presider: Reid Mumford

EJ01: 1:30-1:40 p.m. Developing Items for Physics Identity Survey Applied to Laboratory Settings

Contributed – Kelsey M. Funkhouser, Michigan State University, 567 Wilson Road, East Lansing, MI 48824-2320; kfunkh@msu.edu

Vashti Sawtelle, Marcos D. Caballero, Michigan State University

There is an abundance of work showing that students generally do not have positive views of physics, or see themselves as part of physics. Physics lecture courses can make those views even worse. One tool for improving student experiences is to engage students in authentic science practices. Laboratory courses are intended to be an opportunity for students to engage in activities that reflect the practices of a physicist. We are developing a survey that can be used to systematically determine students' views toward physics and where they position themselves with respect to physics (physics identity). Using the communities of practice framework, we are designing a study to measure how students' physics identities are affected by physics laboratory courses. We will be presenting on the development of items for the survey through student interviews and classroom observations.

EJ02: 1:40-1:50 p.m. Reducing the Performance Gap Between Majors in Introductory Physics Laboratory

Contributed – Yuri B. Piedrahita, Purdue University, 139 Airport Rd Apt 6, West Lafayette, IN 47906; ypiedrah@purdue.edu

Raul Portuondo, University of Puerto Rico at Mayaguez

There is an assumed belief about the differences in performance between students from different disciplines. For example, engineering students are expected to perform better in the Physics Lab than students from Biology or Pre-med. With the aim of collecting evidence to challenge such assumption, a quasi-experiment was developed with undergrad students pursuing different majors in an introductory physics laboratory at a U.S. university. During one semester students of engineering, biology, and pre-med were part of both experimental and control groups. The intervention consisted in a pedagogy explicitly combining elements of physics, mathematics, and experiments. Different students' scores were used to compare performance across disciplines. While there were significant differences between students of different disciplines in the control group, there were no differences for students in the experimental group. It suggests that the assumed differences in performance between majors could be an issue of methodology rather than default deficiencies.

EJ03: 1:50-2 p.m. Peer Assessment and Learning Attitudes

Contributed – Scott S. Douglas, Georgia Institute of Technology, North Ave. NW, Atlanta, GA 30332; scott.s.douglas@gatech.edu

Edwin Greco, Mike Schatz, Georgia Institute of Technology

Shih-Yin Lin, National Changhua, University of Education, Taiwan

Georgia Tech has developed the "Your World is Your Lab" curriculum centered around inquiry-based, out-of-clasroom laboratory activities with peer assessment, and has deployed this curriculum in many classroom contexts. Our previous work has found an improvement in expert-like student behavior through quantitative and qualitative analysis of peer assessments. Our current work includes an analyses of student responses to the Colorado Learning Attitudes about Science Survey (CLASS), which we fit into a larger metacognitive framework about student engagement with peer assessment.

EJ04: 2-2:10 p.m. Categorizing Student Online Responses to Dorm Room Prelab Experiment Questions

Contributed – Katherine Ansell, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, IL 61801; crimmin1@illinois.edu

Mats Selen, University of Illinois at Urbana-Champaign

At the University of Illinois, we have been engaged in lab reform at the introductory level which includes prelab assignments where students do simple physics experiments in their dorm rooms. In these assignments, students answer free-response questions in an online system and receive email feedback from their lab instructor. The free-response format is necessary to capture both the natural variation in experiment materials available to students outside of the classroom and the nature of the mistakes students make in their experiments. However, providing feedback for each student is not scalable to the staffing needs of a large-enrollment course. We have observed that student responses that require feedback tend to fall into a small number of outcome categories, in which each response can be addressed using the same feedback. In this talk we will present data supporting these outcome categories and discuss the implications for scalability solutions.

EJ05: 2:10-2:20 p.m. Coding Scheme for Comparing Among Research-based and Instructor-designed Activities

Contributed – Amin Bayat Barooni, Georgia State University, Department of Physics and Astronomy, One Park Place, Room 425, Atlanta, GA 30302-3999; abayatbarooni1@student.gsu.edu

Myat Thinzar Pho, Ibraheem C. Robins, Joshua S. Von Korff, Georgia State University

Jacquelyn J. Chini, University of Central Florida

Many research-based curricula have integrated laboratory activities; for instance, Realtime Physics, Workshop Physics, the Investigative Science Learning Environment and others. These curricula emphasize "minds-on" student interaction in contrast to stereotypical "cookbook" lab activities, in which students are expected to perform procedural steps without any emphasis on student-led design or analysis. Physics teachers may have goals and ideas about using labs that do not coincide with the thoughts of the designer of a published activity. Therefore, a teacher may find that no PER-based activity exactly meets his/her instructional goals. In this situation, teachers could use features of different lab activities to create an activity that does respond to their goals. We have analyzed both research-based and cookbook activities to find reliable codes for categorizing their properties. Additionally, we have used these codes to classify research-based design labs to help instructors to select those that match their instructional goals.

EJ06: 2:20-2:30 p.m. Physics Students' Use of Algodoo in Modeling

Contributed– Elias Euler, Uppsala University, Lägerhyddsvägen 1, Uppsala, 75237 Sweden; elias.euler@physics.uu.se*

Bor Gregorcic, Uppsala University

Electronic devices are ubiquitous in today's society and their inclusion in the classroom alongside traditional laboratory equipment may allow students to interact with physics content in ways that supplement more formal approaches to doing physics. We investigate how one digital tool, Algodoo (a sandbox software with a user-friendly interface that allows users to create simple models of physical phenomena in a quick and intuitive way), promotes communication among students as they complete a physics task using both physical equipment and the Algodoo software on an Interactive WhiteBoard (IWB). While students recreate the physical laboratory setup in Algodoo, they move between physical, 'semi-formal,' and formal domains with an expanded set of resources for communication. We show that tracking the information that students transduct into, out of, and within the Algodoo environment is a means of gaining insight into what students consider relevant in a physics context.

*Sponsored by Cedric Linder and Bor Gregorc

Session EK: PER: Examining Content Understanding and Reasonings

Location: Marriott - Covington Ballroom II
Sponsor: AAPT
Date: Tuesday, July 25
Time: 1:30–2:50 p.m.

Presider: Xian Wu

EK01: 1:30-1:40 p.m. Introductory Physics Students' Mathematics and Physics Epistemological Resources

Contributed – Erin Scanlon, 1000 W. Court Street, Seguin, TX 78666; emscanlo@gmail.com

A qualitative investigation was conducted to determine the epistemological resources (Hammer & Elby, 2001) employed by introductory physics students while solving mathematics and physics problems. Students enrolled in introductory, algebra-based physics were observed solving problems thinking aloud during one-on-one office hour sessions. The epistemological resources utilized during these problem-solving sessions and their associated usage patterns were investigated by analyzing transcripts of students' think-aloud wording. Differences between the resources employed while solving mathematics problems and while solving physics problems will be discussed.

EK02: 1:40-1:50 p.m. The Role of Prior Knowledge and Gender in Conceptual Performance

Contributed – John Stewart, West Virginia University, 235 White Hall, Morgantown, WV 26501; jcstewart1@mail.wvu.edu

Rachel Henderson West Virginia University

This study investigates the role of conceptual prior knowledge (CPK) in student performance on the Conceptual Survey of Electricity and Magnetism (CSEM) as well as qualitative questions given as quizzes and tests. Structural Equation Modeling was used to functionalize CPK as a latent variable that captures the amount of conceptual performance that is not explained by quantitative performance. Ten semesters of data were collected to produce a sample of N=1407 students. The CPK of male students was .44 standard deviations higher than female students. Linear regression was used to investigate CPK, test average, and gender and showed, that once CPK was controlled for, no significant gender effect was measured except in pretest score. A growing gender gap on the CSEM with pretest score was explained by the systematic mismeasurement of the CPK of women by the CSEM pretest.

EK03: 1:50-2 p.m. The Mediating Relationship of Differential Products in Understanding Integration

Contributed – Andrew F. Heckler, Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; heckler.6@osu.edu

Nathaniel Amos, Ohio State University

We report on a study of student conceptual understanding of differentials, differential products, and integrals and possible pathways to understanding these quantities in the context of introductory physics. We developed a multiple-choice conceptual assessment employing a variety of physical contexts probing physical understanding of these three quantities and administered the instrument to over 1000 students in first and second semester introductory physics courses. Using a regression-based mediation analysis with conceptual understanding of integration as the dependent variable, we found evidence consistent with a simple mediation model: the relationship between differentials scores and integral scores may be mediated by the understanding of differential products. We also find evidence that the physical context of the questions can be an important factor. These results imply that for introductory physics courses, instructional emphasis first on differentials then on differential products in a variety of contexts may in turn promote better integral understanding.

EK04: 2-2:10 p.m. Understanding Partial Derivatives: What Is Held Constant?

Contributed – Paul J. Emigh, Oregon State University, 2410 NW Rolling Green Dr, Apt 41, Corvallis, OR 97330; paul.emigh@gmail.com

Corinne Manogue Oregon State University

Partial derivatives are frequently used to describe physical quantities across many sub-fields of physics. We describe common resources that students use to identify what quantity or quantities are held constant when finding partial derivatives. In particular, we discuss how the use of such resources evolves and diversifies as students are exposed to more contexts, such as electromagnetism and thermodynamics. We also present an example activity from Oregon State University aimed at helping students think about holding different variables constant when finding partial derivatives.

EK05: 2:10-2:20 p.m. Communicating and Using Math in the Optics and Photonics Workforce

Contributed – Brianna Santangelo, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; santanb1@tcnj.edu

Nicholas Young, The Ohio State University

Anne Leak, Kelly Martin, Benjamin Zwickl, Rochester Institute of Technology

Math is an integral part of science industries though so embedded in specialized contexts that it is often hidden. With many physics majors going into industry upon graduation, it is imperative for educators to understand math used in professional contexts. We interviewed employees and managers from optics companies and research labs in New York to better understand how math is used. These interviews were coded using emergent methods to better understand the math skills, expectations, and ways it is communicated on the job. We found that the level of math needed ranged from basic arithmetic to calculus and was often highly contextualized to the task being performed. Communicating math was either highly technical with peers or simplified with customers to develop a common language. These findings have implications for how math is integrated into physics curriculums and how physics education research can connect science use in careers to undergraduate education.

EK06: 2:20-2:30 p.m. How Students Use Far Analogies to Understand New Physics Concepts

Contributed – AJ Richards, The College of New Jersey, 2000 Pennington Rd., Ewing, NJ 08628; aj.richards@tcnj.edu

David Brookes, Florida International University

Eugenia Etkina, Rutgers University

We have documented a small group of preservice physics teachers learning about how a solar cell functions and examined how they use analogical reasoning. In particular, we note how they devise far analogies (analogies to non-physics, everyday-life phenomena, described by Dunbar [1995*] as "long-distance analogies") to "wrap up" a discussion of a certain topic and to demonstrate understanding or attempt to explain the situation to a groupmate who remains uncertain. These far analogies represent important "mileposts" in the conversation, as we observe that students almost always employ them only after they feel confident in their understanding of the concept. We will present several notable examples and discuss implications of their use in student reasoning about new physics ideas.

*K. Dunbar. "How scientists really reason: Scientific reasoning in real-world laboratories." The nature of insight, 18 (1995): 365-395.

EK07: 2:30-2:40 p.m. Student Reasoning About Conservative Fields with Dry-Erasable Tools

Contributed – Elizabeth Gire, Oregon State University, 367 Weniger Hall, Corvallis, OR 97333; giree@oregonstate.edu

Aaron Wangberg, Winona State University

Robyn Wangberg, St. Mary's University

Using multiple representations in physics instruction can help students to develop rich understandings. As part of the Raising Physics to the Surface project, we have developed an activity using geometric representations to help middle-division students understand the connection between changes in electric potential and the line integral of the associated electric field. Students work in groups with a dry-erasable 2-D vector field map and a corresponding potential surface. In this talk, we present examples of student reasoning from classroom video and discuss how the use of the tools support student learning and discussion.

EK08: 2:40-2:50 p.m. Investigate Students' Use of Boundary Conditions Using Symbolic Forms

Contributed – Qing Xu Ryan, California State Polytechnic University Pomona, 3801 W Temple Ave., Pomona, CA 91768; xuqing12357@gmail.com

Gina Passante, California State University Fullerton

Homeyra Sadaghiani, California State Polytechnic University Pomona

Boundary conditions are an important physics topic that physics undergraduates are expected to understand and apply in many different contexts. As part of an effort to examine students' understanding of Boundary Conditions in upper-division courses, think-aloud interviews were conducted in the context of both junior Electricity and Magnetism (E&M) and Quantum Mechanics (QM). In the E&M task, students were given a classical question about electromagnetic waves at the boundary of two media. In the QM task, students were presented with a classic potential well problem. The analysis of the interviews was guided by the use of a theoretical framework: Symbolic forms. We will discuss the similarities and differences of student understanding and reasoning in these contexts (E&M and QM).

EK09: 2:50-3 p.m. Student Difficulties with Operators Corresponding to Observables in Dirac Notation

Contributed – Chandralekha Singh, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Emily Marshman, University of Pittsburgh

Even though Dirac notation is used extensively in upper-level quantum mechanics, many advanced undergraduate and graduate students in physics have difficulty in expressing the identity operator and other Hermitian operators corresponding to physical observables in quantum mechanics using the Dirac notation in terms of the outer product of a complete set of orthonormal eigenstates of an operator. To investigate these difficulties, we administered free-response and multiple-choice questions and conducted individual interviews with students after traditional instruction in relevant concepts in advanced quantum mechanics courses. We discuss the analysis of data on the common difficulties found. We thank the National Science Foundation for support.

EK10: 3-3:10 p.m. Investigating Student Difficulties with the Representation an Operator is Diagonal in the Context of Degenerate Perturbation Theory

Contributed – Christof K. Keebaugh, University of Pittsburgh, 295 Hillcrest Circle, Pittsburgh, PA 15260-3583; ckk10@pitt.edu

Emily Marshman, Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with determining the representation in which a Hermitian operator corresponding to a physical observable (e.g., the Hamiltonian operator corresponding to energy) is diagonal in the context of degenerate perturbation theory (DPT) involving the Zeeman effect in the hydrogen atom carried out in advanced quantum mechanics courses by administering free-response and multiple-choice questions and conducting individual interviews with students. We find that students share many common difficulties related to these concepts. We describe how the research on student difficulties was used as a guide to develop and evaluate a Quantum Interactive Learning Tutorial (QuILT) which strives to help students develop a functional understanding of linear algebra concepts in the context of DPT. We discuss the development of the DPT QuILT and its evaluation in the undergraduate and graduate courses focusing on these issues. We thank the National Science Foundation for support.

EK11: 3:10-3:20 p.m. What Is a Concept? Critiquing Notions of "Concreteness" and "Transfer"

Contributed – Philip B. Southey, University of Cape Town, Rondebosch Cape Town, WC 7708 South Africa; philsouthey@gmail.com

Saalih Allie University of Cape Town

We often make use of the term "concept", but do not analyze exactly what we mean by the term. This presentation will analyze the notion of "an instantiation of a concept" as used in the widely published studies of Kaminski et al. In these studies, students were taught a mathematical concept either by means of concrete instantiations of that concept, or by means of abstract instantiations. For example: "combining two coconuts with two coconuts gives us four coconuts" is a concrete instantiation of the concept of addition, while "2 + 2 = 4" is an abstract instantiation. Kaminski et al. conclude that mathematical concepts are better taught by means of abstract examples. We will argue that the conclusions of these well executed studies are confused because the notion of "instantiation of a concept" is confused. Our argument is based on a Knowledge in Pieces (or Resources) perspective of conceptual change.

Session EL: Citizen Science and International Collaboration

Location: Marriott - Madison Room
Sponsor: Committee on International Physics Education
Co-Sponsor: Committee on Educational Technologies
Date: Tuesday, July 25
Time: 1:30–3 p.m.

Presider: André Bresges

EL01: 1:30-2 p.m. Participating in Scientific Discovery: The Role of Place-based Science Education

Invited – Karl Schneider, Geographical Institute University of Cologne, Albertus Magnus Platz, Cologne, 53332 Germany; karl.schneider@uni-koeln.de

Participatory approaches in science are increasingly relevant. Among others, they provide access to environmental data that otherwise might be unavailable. More importantly, they help bridge the often perceived gap between scientists and citizens, making science more tangible, understandable and relevant. Today's ubiquitous availability of smartphones is particularly helpful to engage a broad audience in scientific discovery. Using NASA's GLOBE program as an example, this talk discusses opportunities of citizen science approaches in an international context. We discuss procedures to communicate scientific methods, to ensure data quality, and to develop proficiency in drawing conclusions using a set of simple analysis tools. With more than 110 countries participating, and a vast range of satellite data available through NASA, the GLOBE approach offers a unique opportunity to link local measurements to regional/global processes. International experience is increasingly important also in schools. The GLOBE community provides an excellent platform to internationalize teacher education.

EL02: 2-2:30 p.m. Smartphones as Mobile Pocket-Labs: Examples and Effects on Learning

Invited – Michael Thees, University of Kaiserslautern, Department of Physics/Physics Education Research Group, Erwin-Schrödinger-Str., 67663 Kaiserslautern, Germany; theesm@physik.uni-kl.de

Pascal Klein, Michael Thees, University of Kaiserslautern

Smartphones and tablets have increasingly become everyday tools, particularly for the younger generation. Until now, various articles have been published about smartphones and tablets as experimental tools in the physics classroom, making use of the manifold sensors such devices are equipped with. Although much conceptual work has been done, there are only few studies analyzing the effects of the use of these Pocket-Labs as experimental tools on learning (compared to best possible 'traditional' ways in physics classrooms settings). In this talk, a survey of examples using smartphones and tablets as experimental tools related to different topics in physics classrooms and in introductory physics courses will be presented. Finally an overview of the results of different studies with quasi-experimental treatment-control group design will be presented and their results will be discussed.

EL03: 2:30-3 p.m. German-American Cooperation in Physics Education for Citizen Science

Invited – Eduard Krause, Universität Siegen, Walter-Felx-Straße 3, Siegen, Nordrheinwestfalen 57068, Germany; krause@mathematik.uni-siegen.de

An important educational task for physics lies in the raising of awareness for a responsible handling of our planet. Therefore it is important to campaign for environmental-physical questions. With citizen science a broad public is supposed to make a contribution to research and to discuss related questions. The basic idea of the science labs presented, is to give an introduction in measuring technologies to a broad interested public. In this way it is possible to create means to collect large amounts of data. However, the theoretical foundations as well as the implementation of related activities require the expertise of several disciplines. International cooperation on these issues has proved to be beneficial. During the talk interdisciplinary and international citizen science-projects of the University of Siegen and Cologne (Köln) will be presented aiming to provide a differentiated view on issues of environmental physics.

Session EM: PER: Diverse Investigations

Location: CC – Ballroom C
Sponsor: AAPT
Date: Tuesday, July 25
Time: 1:30–3:30 p.m.

Presider: John Weis

EM01: 1:30-1:40 p.m. An Online Faculty Community as a Model for Educational Transformation*

Contributed – Edward Price, California State University San Marcos, 333 South Twin Oaks Valley Road, San Marcos, CA 92096; eprice@csusm.edu

Chandra Turpen, University of Maryland, College Park

Melissa Dancy, University of Colorado, Boulder

The Next Generation Physical Science and Everyday Thinking Faculty Online Learning Community (Next Gen PET FOLC) is designed to support faculty teaching physics or physical science courses for preservice elementary teachers using the Next Gen PET curricular materials. Informed by research on faculty change and educational transformation, Next Gen PET FOLC is designed to support faculty development and sustainable educational transformation. The Next Gen PET FOLC includes i) experts who can provide long-term support and promote reflection, ii) an internal structure of faculty clusters, and iii) supporting tools such as curricular materials and communication platforms. We describe initial findings on community members' preparedness to implement the curriculum, sense of community, and scope of participation, as well as a future research agenda.

*This work is supported by the National Science Foundation DUE-1626496. http://www.ngpfolc.org/

EM02: 1:40-1:50 p.m. Analyzing the Community Aspect of Faculty Online Learning Communities

Contributed – Alexandra Lau, University of Colorado Boulder, 850 20th St, Apt 501, Boulder, CO 80302; alau693@gmail.com

Melissa Dancy, University of Colorado Boulder

Charles Henderson, Western Michigan University

In 2015 we ran our first Faculty Online Learning Community (FOLC) to support new faculty in the year following their attendance at the Physics and Astronomy New Faculty Workshop (NFW). FOLC cohorts meet biweekly via a video conferencing program and connect between meetings using an asynchronous communication platform. Previous work shows that participants of the NFW face challenges in implementing techniques learned at the workshop when they return to their home institutions.[1] Our FOLCs are designed to create a support network among members as they navigate these challenges. In this talk I will present the themes regarding community formation that emerged from analysis of post-interviews from members of our four completed cohorts. I will discuss what we are learning about the importance of the "C" in FOLC.

1. C. Henderson, M. Dancy, and M. Niewiadomska-Bugaj, Phys. Rev. ST Phys. Educ. Res. 8, 020104 (2012).

EM03: 1:50-2 p.m. Modeling the Development of Self-Efficacy and Identity for Retention of STEM Students

Contributed – Cabot Zabriskie, West Virginia University, 135 Willey Street, Morgantown, WV 26506; cazabriskie@mix.wvu.edu

John Stewart, West Virginia University

Retention of students in Science, Technology, Engineering, and Mathematics (STEM) disciplines is a significant concern in higher education. Self-efficacy and Identity have been identified as important correlates of academic success that may be important in a robust model of STEM retention. Multiple regression and structural equation modeling (SEM) were used to investigate the relation of these variables and STEM graduation probability. Self-efficacy has been shown to depend on academic domain (physics/math/other science, or the profession); these sub-facets were also explored. To illuminate the relations identified, the student's personality and sense of belonging were also investigated as control variables.

EM04: 2-2:10 p.m. Six Questions that Can Predict the Successful Spread of an Education Development Project*

Contributed – Charles Henderson, Western Michigan University, WMU Physics, 1903 W Michigan Ave., Kalamazoo, MI 49008-5252; charles.henderson@wmich.edu

Courtney Stanford, Renee Cole, University of Iowa

Raina Khatri, Western Michigan University

Jeff Froyd, Texas A&M University

Over 30 years of education research has resulted in many curricular materials and instructional strategies for undergraduate STEM. Yet, the majority of these proven products are not widely used. Based on the research literature, we developed a six-item rubric to predict the likelihood that an education development project will successfully spread. We applied this rubric to 71 education development proposals funded by the National Science Foundation in 2009. The rubric predicted that 80% of these would be unsuccessful in spreading their innovations. Data collected for a subset of these projects, via web searches and interviews with the PIs, suggests that the rubric can be used to make reasonably accurate predictions. A common weakness of development projects is that planning for scale and propagation typically occur after the product is developed. We argue that such planning needs to occur from the very beginning of a project.

*This work was supported by the National Science Foundation under grants #1122446, #1122416, and #1236926.

EM05: 2:10-2:20 p.m. Physics Graduate Retention at The Ohio State University

Contributed – Amber Byrum, 7617 B Cutters Edge Ct., Dublin, OH 43016; byrum.37@osu.edu

Andrew Heckler, Alison Koenka, Christopher Porter, Hanna Lafranconi, The Ohio State University

In an effort to improve retention, student experience, and diversity in graduate physics courses and programs, we are conducting a longitudinal study that examines cognitive and motivational factors through surveys, interviews, and focus groups. We also aim to identify how gender, ethnicity, and academic achievement relate to student experience, student success, and retention for graduate students in physics at The Ohio State University. Here we report on data from the first year of survey data administered to two groups of graduate students (44 total): those enrolled in the core physics courses (typically first and second year students) and those who have completed the core courses but have not completed the candidacy exam. They surveys consist of 100+ items including a number of validated scales measuring cognitive factors relevant to retention and the student experience. The results provide evidence of significant gender differences in measures such as belonging, satisfaction, and cost.

EM06: 2:20-2:30 p.m. Team-based Strategies for Improving STEM Instruction: Characteristics of Successful Teams*

Contributed – Alice R. Olmstead, Western Michigan University, WMU, Kalamazoo, MI 49024; alice.olmstead@wmich.edu

Charles Henderson, Andrea Beach, Western Michigan University

Strategies for improving teaching in higher education have recently begun to shift the focus from individual instructors to the department-level. These department-level change initiatives frequently employ teams. However, literature that explores when teams are likely to be effective mechanisms for improving STEM instruction is limited, and a lack of shared knowledge will likely limit the success of these efforts. Our current work aims to address this shortcoming. In particular, we are synthesizing relevant literature from a variety of domains and considering how these research findings from other contexts could apply here. For example, what is known about the effect of team size on team performance? What types of people should be included on a team? We will use these results to interpret empirical data collected from leaders of team-based STEM change initiatives across the U.S.

*This work is supported by funding from NSF-DUE 1525393.

EM07: 2:30-2:40 p.m. University Students' Negotiation of Physics Identity in Informal Physics Programs

Contributed – Kathleen Hinko, Michigan State University, East Lansing, MI 48824

Claudia Fracchiolla, University of Colorado Boulder, The Center for STEM Learning

Graduate students immersed in research continue to develop their physics identity by engaging in practices that are central to the physics community. However, many graduate students also participate in other relevant practices, such as teaching and outreach. For some, teaching and outreach may be integral to their experience doing physics and building identity, although that may be counter to messaging from advisors or academia about their value. In this work, we investigate university educators' (UEs) negotiation of physics identity after they have volunteered in an after-school physics program for K-12 students. We hypothesize that UEs' physics identity is reshaped by the interactions and experiences they have in the program. We analyze UEs' interviews using a Community of Practice framework. From this analysis, we extract the experiences that affect their physics identity as they negotiate their memberships in the outreach and scientific communities of practice.

EM08: 2:40-2:50 p.m. A Methodological Approach to Understand Complexity in College Physics Mindset

Contributed – Angela Little, Michigan State University, 4101 N. Broadway St. Suite 108, Chicago, IL 60613; angie.little@gmail.com

Vashti Sawtelle, Bridget Humphrey, Michigan State University

Mindset is a long standing area of the psychology literature that focuses on students' response to challenge beliefs about the nature of intelligence, and goals for educational experiences. Current measurement tools, primarily focused on Likert-scale surveys, are limited in their applicability to understanding the complexity of students' college physics experiences. We present novel methodologies to capture mindset in student talk through interviewing and analysis. Ultimately, our goal is to develop design principles for educational environments that support students in embracing challenge and believing it is possible to grow and improve in physics. We argue that finer-grained methodologies for studying mindset are key to understanding how such educational outcomes may be achieved.

EM09: 2:50-3 p.m. Do Students' Learning Orientations Have External Effect on Implementation Success?

Contributed – Andrew J. Mason, University of Central Arkansas, 201 S. Donaghey Ave., Conway, AR 72035-0001; ajmason@uca.edu

An external variable that may affect student perceptions of learning physics, as well as actual in-class performance, entails how students' learning goals are oriented with respect to the course (e.g. pre-professional majors who may primarily be interested in maintaining a strong GPA). Preliminary research at the University of Central Arkansas identifies different learning orientations within the student population of a first-semester introductory algebra-based physics course: learning a problem-solving framework for its own usefulness, learning a framework with course performance goals in mind, and a focus on non-goal-oriented items (e.g. focus on process), with regard to a pre-laboratory metacognitive problem-solving exercise. We discuss potential relationships between these learning orientation categories and standard measures of course performance and pre-post analysis.

EM10: 3-3:10 p.m. Exploring Life-Science Students' Conceptions of the Relevance of Physics

Contributed – Abhilash Nair, Michigan State University, 5510 Timberlane St. Apt. D2, East Lansing, MI 48823; nairabhi@msu.edu

Paul Irving, Vashti Sawtelle, Michigan State University

I present in-progress work of investigating student conceptions of relevance in the introductory physics classroom. This work is situated in the first semester of a studio physics for the life-sciences course aimed at leveraging students' disciplinary expertise in biology and chemistry as they learn physics. Physics is often communicated via policy recommendations and program requirements as being relevant and important for the future of life-science students, but often these students disagree. In trying to address this disconnect, I share analysis of interviews with students in the early weeks of the course to demonstrate that our current understanding of relevance in physics needs to be expanded.

EM11: 3:10-3:20 p.m. Linking Intuition to Embodied Experience: The Case for Regaining Balance

Contributed – Jose P. Mestre, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, IL 61810; mestre@illinois.edu

Jason W. Morphew, Ryan Lin, Patrick J. Kwon, University of Illinois at Urbana-Champaign

People possess knowledge about the physics underlying situations from intuitions, observations and experiences. Sometimes intuitions are in conflict with physics laws as well as physical experiences. We explored the connection between people's embodied understandings and their intellectual understandings of balance. Using embodied cognition, a theory suggesting that conceptual understanding is grounded in embodied experiences, connections between intuitive and embodied knowledge were explored. Participants were asked questions that evoked their intuitions about balancing, performed balancing activities on a balance beam, and finally recalled how they swung their arms when balancing. Fewer than 20% of the participants' intuitive answers about balancing were correct. Furthermore, after balancing, only 50% of the participants correctly recalled how they moved their arms while trying to regain balance. In several cases, people's intuitive knowledge did not align with recall of their experience, suggesting that intuitions and embodied experiences are not well linked.

EM12: 3:20-3:30 p.m. Personality Types and Student Performance in an Introductory Physics Course

Contributed – Andrew D. Meyertholen, University of Toronto, 60 St. George, Toronto, Ontario m5r1a1 Canada; andrew.meyertholen@utoronto.ca

Jason J.B. Harlow, David M. Harrison, Brian Wilson, University of Toronto

Michael Justason, McMaster University

There has been much debate about the roles personality and learning style play in effective learning. We assessed students' personality types in a large introductory physics course for life science students using an instrument similar to the Myers-Briggs Type Indicator. We found significant correlations between personality type and test/exam performance. These results were also reflected in the normalized gains on the Force Concept Inventory. The personality type that performed best in the course was similar to the personality profile of the physics faculty here at Toronto. Further study will help to determine the significance of these findings and whether addressing this effect could improve physics instruction.

Awards Session

Location: CC - Event Center II
Date: Tuesday, July 25
Time: Klopsteg Award: 4–5 p.m. AAPT Alpha Awards: 5–6:30 p.m.

Presider: Janelle Bailey

John C. Brown

2017 Klopsteg Memorial Lecture Award: presented to John C. Brown, University of Glasgow

Black Holes and White Rabbits:

Black holes are the among the most bizarre objects in the universe, possibly even related to how the Universe itself began, and a goldmine of fascinating challenges for physics teachers and researchers alike. This talk discusses the nature of gravity and its extremes across the universe explaining what the term Black Hole means, and discussing how and where they form. It also addresses how we detect them and demonstrates many of their weird properties and effects on their surroundings using the speaker's skills as a semi-pro magician.

Ryan Scott

2017 ALPHA Award presented to Ryan Scott

Demonstrating Superposition in the Laboratory: The Hong-Ou-Mandel Effect for Undergraduates

It's no secret that teaching Quantum Mechanics to undergraduate students is challenging. Concepts like superposition and entanglement are typically discussed in a hand-waving fashion—potentially detrimental to the students' understanding. This undergraduate lab experiment attempts to shine an intuitive light on the theoretical complexities of quantum mechanics through a quantum optics experiment: the Hong-Ou-Mandel effect. The effect demonstrates measurable entanglement and superposition through the creation of entangled quantum states between two photons—via a nonlinear crystal—which are measured at two correlated detectors; coincidence counts were monitored, and as the photons' polarizations were made indistinguishable relative to the detectors, quantum interference was observed. The experiment was constructed in a collinear fashion in fiber-based optical equipment using periodically-poled potassium titanyl phosphate as the nonlinear crystal, a polarizing beam splitter as the projective device, and two detectors connected by a correlation device to measure coincidence counts.

2017 ALPHA Award presented to Brandon Thacker

Nonlinear Dynamics and Chaos in Introductory Physics

Nonlinear dynamics and chaos are prominent features in nature and deserve a thorough introduction in the undergraduate physics curriculum. For most students at this level, chaos theory is a concept of very little if any exposure. It is not difficult to build a system that exhibits some form of chaos, a simple double pendulum would do the trick! However, it is no trivial matter to create an apparatus that does so while allowing for complete user control over system parameters and precise measurement of the state of the system as time evolves. These are some of the requirements needed for a chaotic apparatus to be successful in the Advanced Lab setting. The "Mechanical Chaotic Oscillator" (MCO) presented fulfills these needs in an effective and elegant way, combining both qualitative and quantitative features to enhance the learning experience.

PST2: Posters

Location: CC - Event Center I
Sponsor: AAPT
Date: Tuesday, July 25
Time: 5–6:30 p.m.

Poster presenters are asked to mount their posters by 8 a.m. The posters will remain available for viewing until 6:30 p.m. Persons with odd-numbered posters will present their posters from 5 to 5:45 p.m; those with even-numbered posters will present from 5:45 to 6:30 p.m..

Teacher Training/Enhancement

PST2A01: 5-5:45 p.m. Graduate Teaching Assistants Use Different Criteria when Grading Introductory Physics vs. Quantum Mechanics Problems

Poster – Emily M. Marshman, University of Pittsburgh, 209 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Ryan Sayer, Bemidji State University

Charles Henderson, Western Michigan University

Chandralekha Singh, University of Pittsburgh

At large research universities, physics graduate teaching assistants (TAs) are often responsible for grading in courses at all levels. Given that grading can play a crucial role in student learning, it is important to understand how physics TAs grade student solutions. This study was designed to investigate whether physics graduate TAs grade students in introductory physics and quantum mechanics using different criteria and if so, why they may be inclined to do so. To investigate possible discrepancies in TAs' grading approaches in courses at different levels, we implemented a sequence of instructional activities in a TA professional development course which asked TAs to grade student solutions of introductory physics and upper-level quantum mechanics problems and explain why, if at all, their grading approaches were different or similar in the two contexts. We analyzed the differences in TAs' grading approaches in the two contexts and discuss the reasons they provided for the differences in their grading approaches in introductory physics and quantum mechanics in individual interviews, class discussions, and written responses. We find that there are differences in these two contexts and a majority of the TAs were significantly stricter in grading in quantum mechanics. Unlike the introductory physics context, in quantum mechanics, they penalized students for not showing evidence of understanding. The findings of this study have implications for the professional development of the TAs.

PST2A02: 5:45-6:30 p.m. Infusing Argumentation in an Integrated Unit for Future Elementary Teachers

Poster – Carina M. Rebello, Purdue University, Physics Bldg., Rm. 245, 525 Northwestern Ave., West Lafayette, IN 47907-2040; rebelloc@purdue.edu

Yuri Piedrahita Uruena, Chandan Dasgupta, N. Sanjay Rebello, Purdue University

The Next Generation Science Standards (NGSS Lead States, 2013) and science standards of many states emphasize meaningful integration of practices of engineering and engineering design in K-12 science instruction. Scientific argumentation has been highlighted in NGSS as one of the key science and engineering practices. Most current courses that prepare K-12 teachers do not include integrated experiences and/or argumentation for learning science. We describe an integrated instructional unit that infuses argumentation while learning heat transfer in the context of an engineering design challenge in a physics course for future elementary teachers. We will describe the underlying framework and challenges of implementation. We also discuss the impact on student learning and refinement of their design. The project supports of one of the central goals of the Center for Advancing the Teaching and Learning of STEM (CATALYST) at Purdue University to positively impact the integration of STEM teaching and learning in K-12 classrooms.

PST2A03: 5-5:45 p.m. Next Gen PET FOLC: An Online Faculty Community*

Poster – Edward Price, California State University San Marcos 333 South Twin Oaks Valley Road, San Marcos, CA 92096; eprice@csusm.edu

Participation in a professional community can help faculty improve their instruction, conduct classroom research, and study student thinking. The Next Generation Physical Science and Everyday Thinking Faculty Online Learning Community (Next Gen PET FOLC) is a community of faculty teaching physics or physical science courses for preservice elementary teachers using the Next Gen PET curricular materials. The community includes i) experts who can provide long-term support and promote reflection, ii) an internal structure of faculty clusters, and iii) supporting tools such as curricular materials and communication platforms. Participating faculty develop expertise through collaboration and knowledge generation. By providing structure and support, together with these high-quality, flexible curricular materials, Next Gen PET FOLC supports faculty development and far-reaching, sustainable educational transformation. This poster will describe the Next Gen PET FOLC, faculty activities, and initial outcomes.

*This work is supported by the National Science Foundation DUE-1626496. http://www.ngpfolc.org

PST2A04: 5:45-6:30 p.m. Next Gen PET: An NGSS-Aligned Curriculum for Preservice Elementary Teachers

Poster – Fred M. Goldberg, San Diego State University, 6475 Alvarado Road, suite 2026, San Diego, CA 92120; fgoldberg@sdsu.edu

Next Generation Physical Science and Everyday Thinking (Next Gen PET)[1] is a research-based, guided inquiry curriculum for preservice and inservice elementary teachers, designed to provide students with learning experiences aligned with the Next Generation Science Standards. Versions are available for either small or large enrollments, and covering either physics or physical science content. An extensive online instructor's guide (2) includes student and instructor materials, homework activities, videos of experiments and demonstrations, classroom video clips of student interactions, test banks, etc. An associated online faculty learning community (3) provides an opportunity for faculty to collaboratively improve their instruction, study student thinking and conduct classroom-based research using the Next Gen PET curriculum. This poster will describe the curriculum, instructor resources, student learning outcomes, and online faculty community.

(1) Supported by grants from the National Science Foundation and the Chevron Foundation (2) http://nextgenpet.iat.com (3) http://www.ngpfolc.org

PST2A05: 5-5:45 p.m. Sparking Curiosity: Physical Science for Elementary Teachers

Poster – Wendy K. Adams, University of Northern Colorado & Colorado School of Mines, 501 20th Street, Greeley, CO 80631; wendy.adams@unco.edu

Heather Taffe, Ansel Foxley, Kui Chen, University of Northern Colorado

Adrianne N. Larson, Chicago Public Schools

PhysTEC support has allowed three new faculty members to adopt our research-based curriculum in the Physical Science Concepts for Elementary Teachers course at the University of Northern Colorado. This curriculum frames the material in contexts that students are personally interested in and uses several different interactive engagement techniques including Peer Instruction, Just in Time Teaching, and devotes nearly half the instructional time to hands on activities appropriate for the elementary classroom. In this poster we will share pre/post conceptual data as well as CLASS results for the course before and after this new curriculum. The new instructors are showing student normalized learning gains between 64% and 76% and their students' personal interest in physics, as measured by the CLASS, increases between 6% and 22% as compared to decreasing by 13% when taught traditionally.

PST2A06: 5:45-6:30 p.m. A Pre-service Teacher Education Project: Developing and Teaching IOLab Activities

Poster – Rebecca J. Rosenblatt, Illinois State University, 218 Willard Ave., Bloomington, IL 61701; rjrosen@ilstu.edu

Raymond Zich, Illinois State University

This study investigated the impact of a new lab design project on pre-service teacher preparation. Students enrolled in Illinois State University's junior level physics technology and teaching course completed a five-week lab design project. This project had them build a lab that would teach Newton's laws using IOLab technology. The project guided the pre-service teachers through the major steps of curriculum design and culminated in their teaching the labs they created in a general education physics course. We will present a brief summary of TPACK and the basic education theory behind this project, the development stages for the project, the difficulties encountered in implementing this class project, summaries of the labs created by the pre-service teachers, the learning gains and survey results from the general education students who did the labs, and reflections on the project as a whole for teacher preparation.

PST2A07: 5-5:45 p.m. A STEM Integration Program for K-12 Teachers*

Poster – Jennifer L. Docktor, University of Wisconsin - La Crosse 2030 Cowley Hall, 1725 State St., La Crosse, WI 54601; jdocktor@uwlax.edu

Gubbi Sudhakaran, University of Wisconsin - La Crosse

Jerry Redman, Winona State Univeresity

Josh Hertel, Universit,y of Wisconsin - La Crosse

Mike LeDocq, Western Technical College

The "iTEAMS" project at the University of Wisconsin – La Crosse provides professional development (PD) in Integrating Technology, Engineering, Arts, and Mathematics with Science to in-service middle school and high school teachers from high-needs school districts during summer institutes and ongoing weekend workshops. The PD is aligned with the Next Generation Science Standards and is designed to include engineering and robotics projects. We will summarize activities and findings from the first year of the PD and describe future plans.

*This project is funded by a U.S. Department of Education Mathematics and Science Partnerships Program grant through the Wisconsin Department of Public Instruction

PST2A08: 5:45-6:30 p.m. Closing the STEM Skills Gap with Guitars

Poster – Debbie A. French, Wilkes University, 38 Holiday Dr. Apt. 146, Kingston, PA 18704; frenchd14@yahoo.com

Sean Hauze, San Diego State University

Tom Singer, Sinclair Community College

Richard M. French, Purdue University

Doug Hunt Southern, Wells High School

Science, technology, engineering, and mathematics (STEM) jobs are expected to grow at a rate of three times that of STEM jobs, resulting in a deficit of 3 million STEM graduates by 2018. Approximately two-thirds of manufacturing companies report a shortage of workers with 21st century STEM skills. This deficit of qualified workers is known as the skills gap. Additionally, teachers are being called upon to implement the Next Generation Science Standards (NGSS) which incorporate science and engineering practices in the K12 science curriculum. This preliminary quantitative study with supporting qualitative data explored K16 STEM teachers' perceptions of their own STEM skills and the skills they are incorporating in their classes before and after a week-long professional development opportunity using the manufacture of an electric guitar as a vehicle to teach STEM. Particular emphasis will be placed on STEM skills within high school physics courses.

PST2A09: 5-5:45 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Physics Instructors and Teaching Assistants Using the Force Concept Inventory*

Poster – Alexandru Maries, University of Cincinnati, 3405 Telford Street, Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

The Force Concept Inventory (FCI) has been widely used to assess student understanding of introductory mechanics concepts by a variety of educators and physics education researchers. One reason for this extensive use is that many of the items on the FCI have strong distractor choices that correspond to students' alternate conceptions in mechanics. Instruction is unlikely to be effective if instructors do not know the common alternate conceptions of introductory physics students and explicitly take into account students' initial knowledge state in their instructional design. Here, we discuss research involving the FCI to evaluate one aspect of the pedagogical content knowledge of both instructors and teaching assistants (TAs): knowledge of introductory student difficulties related to mechanics as they are revealed by the FCI. We used the FCI to design a task for instructors and TAs that would provide information about their knowledge of common student difficulties and used FCI pre-test and post-test data from a large population (~900) of introductory physics students to assess this aspect of pedagogical content knowledge of physics instructors and TAs. We find that while both physics instructors and TAs, on average, performed better than random guessing at identifying introductory students' difficulties with FCI content, they did not identify many common difficulties that introductory physics students have, even after traditional instruction. Moreover, the ability to correctly identify students' difficulties was not correlated with the teaching experience of the physics instructors or the background of the TAs.

*Work supported by the National Science Foundation

PST2A10: 5:45-6:30 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Teaching Assistants Using the Test of Understanding Graphs in Kinematics*

Poster – Alexandru Maries, University of Cincinnati, 3405 Telford Street, Cincinnati, OH 45220; mariesau@ucmail.uc.edu

Chandralekha Singh, University of Pittsburgh

The Test of Understanding Graphs in Kinematics (TUG-K) is a multiple choice test developed by Beichner in 1994 to assess students' understanding of kinematics graphs. Many of the items on the TUG-K have strong distractor choices which correspond to students' common difficulties with kinematics graphs. We evaluate one aspect of the pedagogical content knowledge of first year physics graduate students enrolled in a teaching assistant (TA) training course related to topics covered in the TUG-K. We used the TUG-K to design a task forTAs that would provide information about their knowledge of common student difficulties and used the TA data and the data from Beichner's original paper for introductory physics students (which was collected from over 500 college and high-school students) to assess this aspect of the pedagogical content knowledge (PCK) of the graduate students, i.e., knowledge of student difficulties related to kinematics graphs as they are revealed by the TUG-K. We find that, although the graduate students, on average, performed better than random guessing at identifying introductory student difficulties on the TUG-K, they did not identify many common difficulties that introductory students have with graphs in kinematics. In addition, we find that the ability of graduate students to identify the difficulties of introductory students is context dependent and that discussions among the graduate students improved their understanding of student difficulties related to kinematics graphs. Moreover, we find that the ability of American graduate students in identifying common student difficulties is comparable with that of foreign graduate students.

*Work supported by the National Science Foundation

Labs/Apparatus

PST2B01: 5-5:45 p.m. Identifying Common Difficulties in Causal Reasoning: The Effects of Bias

Poster – Lindsay Owens, The University of Cincinnati, 3843 Mantell Ave., Cincinnati, OH 45236; owensly@mail.uc.edu

Kathy Koenig, University of Cincinnati

Lei Bao, The Ohio State University

Students in algebra-based physics laboratory classes take a pre- and post-test designed to measure their scientific reasoning abilities across multiple domains. Students typically show improvements in the domains of control variables and probability, but show little to no improvement in higher order reasoning skills, such as causal reasoning. This poster shows a positive correlation between student causal reasoning skills and their total reasoning score as measured by the iSTAR. In addition, this poster shows that all students, regardless of causal reasoning skill ability, demonstrated difficulty with causal reasoning when pre-existing biases were present. In order to identify difficulties associated with bias in causal reasoning, students answered a series of questions which addressed a commonly believed claim that red cars get more speeding tickets.

PST2B02: 5:45-6:30 p.m. Helping Students Master Uncertainties in Measurements

Poster – Scott W Bonham, Western Kentucky University 1906 College Heights Blvd., Bowling Green, KY 42101; Scott.Bonham@wku.edu

Brian Luna, Kolton Jones, Western Kentucky University

Uncertainties are an important part of scientific measurement, but one with which many students struggle. We present a set of activities that we have implemented in introductory physics laboratory sessions to help students understand the concept, mechanics and importance of uncertainties. These activities seek to help students visualize the meaning of the standard deviation of the mean/standard error, give them practice calculating the standard error and propagating uncertainties through multiple calculations, and recognize the need for uncertainties in a "real life" application. For this, students measure parameters of a plastic "boat", "cargo" it is to carry, and its "sea", to calculate the maximum cargo—with uncertainties—that will not sink. We find that the full set of instructional interventions leads the majority of the students to consistently report the uncertainties of their measured and calculated values in their reports for most of the rest of the semester.

PST2B03: 5-5:45 p.m. Improving Scientific Reasoning Development in Elementary Physics Lab Students*

Poster – Larry J. Bortner, University of Cincinnati, 2825 Campus Way, Braunstein 345, Cincinnati, OH 45221; bortnelj@ucmail.uc.edu

Kathleen Koenig, Lindsay Owens, Krista Wood, University of Cincinnati

Lei Bao, Ohio State University

First semester physics lab curriculum has been developed at the University of Cincinnati to promote scientific thinking and its application. In concert with this, the Inquiry for Student Thinking and Reasoning (iSTAR) assessment has been developed to probe student abilities in scientific reasoning. This presentation will provide details on how the labs have resulted in significant improvement in one particular aspect of scientific reasoning, the control of variables (COV). However, this improvement occurs within the first four labs, suggesting that revisions to following labs could further impact student COV abilities. Data will be presented for how the scores of students broken up into post-iSTAR tertiles correlate with performance on the lab exam and second semester pre-assessments CSEM and LOCE.

*Partial support from NSF DUE 1431908

PST2B04: 5:45-6:30 p.m. Keeping Introductory Physics Laboratory From Being Mind Numbingly Boring – Part 2

Poster – Jacob Millspaw, IPFW, Department of Physics, Fort Wayne, IN 46805; masters@ipfw.edu

Mark F. Masters, IPFW

In a previous poster (2015 Summer Meeting) we presented our preliminary work on making the first semester introductory physics laboratory more experiment focused. In this case, students were given goals to accomplish such as determine a model for static frictional forces. We have continued the evolution of the laboratories to include more explicit methods for determining models. But there are more significant projects, such as building a balance that is capable of measuring a 2-3 g mass with a precision of 10 mg. This project requires the students to think about the physics and apply what they know to come up with a solution for a difficult problem.

PST2B05: 5-5:45 p.m. Measurement of the Speed of Sound in Various Liquids

Poster – Bob Powell, University of West Georgia, Department of Physics, Carrollton, GA 30118; bpowell@westga.edu

Ben Jenkins, University of West Georgia

Iowa Doppler Products' (IDP) instrumentation is designed to measure the speed of sound through a variety of media. This equipment has been used as the initial research project for undergraduate physics majors at the University of West Georgia. These students have studied the speed of sound in the following liquids: water, salt water containing various concentrations of sodium chloride, Coca Cola products, and water-antifreeze mixtures. Errors in the speed of sound in water were typically about 0.5%. Measurements of the speed of sound in other substances are being planned.

PST2B06: 5:45-6:30 p.m. Model-based Reasoning During Electronics and Optics Lab Activities: Instructor Perspectives

Poster – Dimitri R. Dounas-Frazer, University of Colorado Boulder, Department of Physics 390 UCB, Boulder, CO 80309-0390; dimitri.dounas-frazer@colorado.edu

Jacob T. Stanley, H. J. Lewandowski, University of Colorado Boulder

Conducting physics experiments requires constructing, using, and refining theoretical models and physical apparatuses, a nonlinear and recursive process we call "modeling." Developing proficiency with modeling was identified as an important learning outcome for undergraduate physics lab courses by both AAPT and faculty members at our home institution. Our long-term goal is to create educational materials that will support lab instructors to develop their students' modeling skills. To this end, we have previously studied students' approaches to completing experimental physics activities. However, instructor perspectives are also needed to build a comprehensive foundation for future development of useful and relevant educational materials. Accordingly, we interviewed more than 30 instructors about specific electronics and optics lab activities. Interviews focused on how those activities were designed to engage students in some aspects of modeling, but not others. We report results from this study and discuss implications for the development of objectives for modeling assessments.

PST2B07: 5-5:45 p.m. Quantitative Exploration of Ohm's Law with Computer Fans

Poster – Robert Charles Ekey, University Of Mount Union, 1972 Clark Ave., Alliance, OH 44601-3993; ekeyrc@mountunion.edu

Brandon Mitchell, West Chester University

Andrea Edwards, Roy McCullough, William Reitz, University of Mount Union

Recently, we demonstrated small computer fans are a suitable replacement of tungsten filament bulbs for qualitative analysis of simple circuits where the current is related to the rotational speed of the fan.[1] In this poster, we demonstrate that fans can be used for quantitative measurements as well. Ohm's law can be verified from measurements of the voltage across and current through the fan, which exhibits a linear relationship enabling an effective resistance of the fan to be calculated. These can then be verified for series, parallel and combination circuits containing one or two fan models. Though the fan is a complex circuit element, these results demonstrate both the qualitative and quantitative benefits of using fans as an effective tool to teach simple circuits. As bulbs do not allow for these simplistic quantitative measurements, fans are arguably a suitable, if not better, replacement for light bulbs.

1. Robert Ekey, Andrea Edwards, Roy McCullough, William Reitz, and Brandon Mitchell, The Physics Teacher 55, 13 (2017).

PST2B08: 5:45-6:30 p.m. Raman Spectroscopy as a Bridge Between Advanced and Research Laboratories

Poster – Eugenii U. Donev, Sewanee: The University of the South, Dept of Physics and Astronomy, 735 University Ave, Sewanee, TN 37383-1000l; eudonev@sewanee.edu

Daniel Rosales, Ahsanul Kabir, Tyler Blankenship, Sewanee: The University of the South

Raman spectroscopy is a versatile technique that 'fingerprints' materials according to the radiative transitions between their molecular vibronic states. The range of suitable samples is vast, and so are the scientific, engineering, and industrial applications. However, Raman instruments are not common in physics departments at small colleges. At Sewanee, we have introduced undergraduate physics majors to regular and surface-enhanced Raman spectroscopy (SERS) through an iterative approach that connects the advanced laboratory course to the research activities of the faculty. Students built and optimized a Raman system as a semester-long research project, and then used electromagnetic simulations, nanolithography, and thin-film deposition as a summer research project to fabricate SERS-active substrates. These efforts paved the way for augmenting the advanced laboratory with Raman-related experiments, which in turn inspired a student to construct a micro-Raman system for measuring grains in rock and meteorite samples as a capstone research project.

PST2B09: 5-5:45 p.m. Simulating Radioactive Decay with Dice

Poster – Ian Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark; bearden@nbi.dk

Louisa Uglebjerg, Niels Bohr Institute

Six-sided dice have long been used to simulate radioactive decay. One takes N_0 dice, rolls them and removes all those showing a given number leaving N_1 dice. This is repeated and the number of dice remaining in each step is plotted, giving a reasonable exponential decay curve. We have expanded this by including dice with different numbers of sides (4, 6, 8, 10, 12, 20, 24). In addition to being catnip for the D&D set, an number of processes can be simulated since each of the various die types can represent and isotope with a different half life. One can also use the data generated to teach basic statistics needed for counting measurements as well as a discussion of differences between the dice generated data and a true exponential decay function. Finally, while all of these dice experiments can easily be done numerically, we argue that the physical interaction of the student with the apparatus removes the "black box" aspect of many simulations and allows students to directly see what is actually taking place.

PST2B11: 5-5:45 p.m. A Timbre Tutor for Music Students

Poster – Gerald T. Ruch, University of St. Thomas 2115 Summit Ave., St. Paul, MN 55105; gtruch@stthomas.edu

John Walker, University of St. Thomas

We present a tool for determining the difference between a "well played" note and a "poorly played" note on a musical instrument by measuring the timbre, that aspect of a sound sample separate from pitch or volume. In our subjective measure, warm tones are considered "good" and bright tones are considered "bad." Warm versus bright is quantified by determining the fundamental frequency of the note and examining the harmonics. A note with many harmonics sounds bright while a note with few harmonics sounds warm. We have built a smartphone app that calculates the harmonic average of an incoming signal and presents the results in real time. This app can be used by a music student during solo practice sessions between lessons to develop good tone on their instrument.

PST2B12: 5:45-6:30 p.m. Improving a Systematic Lecture Demonstration for Hypothetical-Deductive Reasoning Skill

Poster – Jun-ichiro Yasuda, Yamagata University, Yamagata, Kojirakawa, 1-4-12, Yamagata, 990-8560 Japan; baryogenesis@gmail.com

We developed a lecture demonstration experiment to improve students' scientific reasoning skills. In this experiment, students roll two objects (e.g. metal cylinder, ping-pong ball etc.) down a slope, compare their velocities, and study the factors that affect the motion of the objects. The goal given to the students is to predict the result of the experiment with a pipe and a spool. In order to make a certain prediction, students conduct preliminary experiments repeatedly with various objects. This practice has two features. First, students design the procedures of the experiments. Second, students conduct scientific reasoning with a worksheet. We evaluated students' scientific reasoning skills with Lawson's Classroom Test of Scientific Reasoning (CTSR). We found that through this practice the average CTSR score significantly increased (df = 91?p < .01?d > 0.4). Especially, the average score of hypothetical-deductive reasoning skill increased when students experienced falsification repeatedly.

PST2B13: 5-5:45 p.m. Using a Michelson Interferometer to Detect Sounds

Poster – Timothy Todd Grove, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805; grovet@ipfw.edu

We present a laser experiment for students beyond their first year in physics. This experiment not only gives students experience with laser interferometry, it also provides cross course learning (electronics) and play. The experiment is based upon a Michelson interferometer; a sound source vibrates one of its reflecting mirrors to produce a time changing signal. Usually the sound source is a radio connected to a small speaker, but students are free to play with other sound vibrating schemes. The interference fringes vibrate with frequencies similar to the sound source. A photodetector then detects the changing fringes and a simple computer program converts the photo signal into an audio file. Simple electronics circuits provide access to the radio signal sent to the sound speaker. Then by comparing the "true" radio signal with the signal recorded via the photodetector, we can analyze the performance of our sound recording system.

PST2B14: 5:45-6:30p.m. What Fraction of the Human Population Can Perceive Polarization?

Poster – Scott Dudley, TASIS England, Coldharbour Lane, Thorpe, Surrey TW20 8TE United Kingdom; sdudley@tasisengland.org

Francesco Insulla, Hannah Milliman, Andre Catao, Mackenzie E. Winton. TASIS England

Some people are able to perceive the polarization of light. The effect, known as Haidinger's Brush, results in them perceiving a faint fuzzy yellow and blue bowtie-cross when looking at polarized light. Here we determine whether subjects can see Haidinger's Brush by testing them with a polarized LCD screen, and estimate the fraction of the population that possess this ability.

PST2B15: 5-5:45 p.m. X-ray Attenuation and CT Image Reconstruction Using Simple X-ray Device

Poster – Haraldur Audunsson, Reykjavik University, Menntavegur 1, Reykjavik, 101 Iceland; haraldura@ru.is

Thordur Helgason Reykjavik University

Part of our introduction to x-ray attenuation, computed tomography (CT), and its use in medical imaging, is done by using a simple x-ray device. A small object in the x-ray beam casts a shadow on a fluorescent screen, which is photographed by a common digital camera. Students ascertain to what extent components of the imaging system are linear, i.e. the x-ray lamp, the fluorescent screen and the camera, and use the photos to evaluate beam attenuation and beam hardening. A single slice CT through the small object is made by manually rotating it by a small angle and taking a photo of the fluorescent screen at each step, eventually forming a sinogram. Computations based on filtered back projection are used to reconstruct a single slice CT. The transparency of this set up and hands on brings out the underlying principles and reinforces practical skills.

PST2B16: 5:45-6:30 p.m. "Publishing and Reverse Game Play" Investigation

Poster – Timothy Todd Grove, IPFW, 2101 E. Coliseum Blvd., Fort Wayne, IN 46805; grovet@ipfw.edu

One of the recent changes we were obliged to make in our introductory physics courses was to address general education goals. Among these goals was a requirement regarding teaching "how the natural sciences generate knowledge." To help meet this goal, we introduced reverse game play into the first laboratory investigation. In reverse game play, students try to determine the rules of a game by simply watching it being played. However, this, by itself, ignores the role of scientific publishing. To simulate the role of publication, students write their discoveries on a chalkboard for all to see. The lab instructor serves the role of journal editor and only allows testable and non-trivial information to be posted. Students can then challenge or build upon the information on the chalkboard. Poker chips are given/taken from student groups to mark their progress.

PST2B17: 5-5:45 p.m. A Lab on Kepler's Laws that Introduces Students to Python and Coding in General

Poster – Glenda Denicolo, Suffolk County Community College, 91 Ontario Street, Port Jefferson Station, NY 11776; glenda.denicolo@gmail.com

Michael A. Zingale, Stony Brook University

Aligned with AAPT recommendations to incorporate computational physics into the curriculum, we prepared a coding exercise about the verification of Kepler's laws and offered it to our second semester calculus-based physics students as an in-class laboratory activity. The exercise is coded in Python using Jupyter notebooks. The notebooks are placed in a github repository, and are deployed to the students via mybinder.org. Binder opens the notebooks in a browser for the students, avoiding the need to install any software. During the two- hour lab, students followed the instructions in the notebook, which gradually introduced them to Python commands, and explained the fourth order Runge-Kutta integration method applied to calculate orbits. Students are guided in gradual steps on how to add lines to the code, change initial conditions and run the integration for new orbits to collect data. The information collected is used to write a lab report on the verification of Kepler's three laws.

PST2B18: 5:45-6:30 p.m. A Low Cost Apparatus for Measuring the Speed of Light

Poster – Ian Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100; Denmark bearden@nbi.dk

Jan Oechsle, Niels Bohr Institute

We have a developed a reasonably priced (around $150) apparatus for measuring the speed of light. This consists of two small electronics boards, a lucite beam splitter, a fresnel lens, and a retroreflector. The transmitter board has three LEDs (red, green, blue) which can be chosen as the light transmitter, as well as the circuitry to generate light pulses of 100ns every 0.5-2.microseconds (selectable in 500ns increments via jumper). The receiver board consists of a small detector and associate electronics. Using an oscilloscope to find the time difference between the driver signal of the transmitter board and the arrival time of the collected light, one can obtain results at least as accurate as those from commercial systems costing four to twenty times as much. The low cost allows for a duplication of setups which would otherwise be cost prohibitive for many schools and universities.

PST2B20: 5:45-6:30 p.m. A PSoC-based Linear Detector Array for a Spectrograph

Poster – Mark F. Masters, IPFW, Department of Physics, Fort Wayne, IN 46805; masters@ipfw.edu

Jacob Millspaw, IPFW

Continuing our love affair with the Cypress PSoC mixed signal processor, we built a linear array detector for use in a spectrograph. The detector is a 128 pixel TSL1401 from AMS. The PSoC serves as the bridge to provide timing to the detector, to read in and digitize the signal from each pixel. We use analog to digital conversion at a rate of 1 MSample/second and 12-bit resolution. The PSoC can display the data on a graphical LCD, but also sends the data to computer via a USB port. The exposure time and averaging can be completed on the PSoC. Maximum data rate is over 6 kHz. A Python program provides the communication between the PSoC and the detector. This detection system is used in a simple spectrograph.

PST2B22: 5:45-6:30 p.m. Assessing Technical and Practical Skills in Lab Courses

Poster – Patricia E. Allen, Appalachian State University, 525 Rivers Street, Boone, NC 28608; allenpe@appstate.edu

Some technical and practical skills described in "AAPT Recommendations for the Undergraduate Laboratory Curriculum" include, but are not limited to: using measuring tools and apparatus, understanding limitations to tools/apparatus, trouble-shooting situations, and developing appropriate documentation. At Appalachian State University, multiple technical and practical skills are assessed during both Intermediate (sophomore/junior level) and Advanced (senior level) lab courses. Assessment methods used (including rubrics) together with how assessment results inform modifications to lab activities, will be presented and discussed.

PST2B23: 5-5:45 p.m. Designing Earthquakes for a Low-Cost Shake Table*

Poster – Frederick J. Thomas, Math Machines 1014 Merrywood Dr., Englewood, OH 45322; fred.thomas@mathmachines.net

Robert A. Chaney, Marta Gruesbeck, Sinclair Community College

A servo-powered shake table can be programmed to produce one-dimension scale versions of either real or user-designed earthquakes. Programmed using Excel-like algebraic functions, the table can replicate earthquakes with varying amplitudes (i.e., original Richter magnitude), different maximum accelerations (the primary basis for building codes), varying frequencies, alternative waveforms and more. In addition to teaching about the differences among displacement, velocity and acceleration, the table can assist in teaching about periodic and non-periodic motions. A sample two-part activity asks students to (1) design and build a structure that can withstand a Richter magnitude 5 earthquake, then (2) design a magnitude 4 earthquake to destroy the structure. Since the Arduino family board incorporates a micro SD card, the system can store and replay thousands of alternative motions. Plans for building the table are provided, along with an executable LabVIEW control program and the necessary sketch for implementation via a ChipKIT WF32 board.

*Based in part on NSF-ATE Grants No. DUE-0202202 and DUE-1003381

PST2B24: 5:45-6:30 p.m. Evolution of Technical and Practical Skills Through Intermediate Lab Activities

Poster – Patricia E. Allen, Appalachian State University, 525 Rivers Street, Boone, NC 28608; allenpe@appstate.edu

Scott A. Thomas, Appalachian State University

At Appalachian State University, physics majors are required to take both Intermediate (sophomore/junior level) and Advanced (senior level) labs to graduate. During Intermediate lab, students are initially guided through a series of activities to become familiar with measuring tools and techniques, as well as limitations associated with acquiring data. By the end of the semester, Intermediate students are expected to be independent when designing and completing lab activities. An overview of these activities will be presented, along with how activities have evolved over time and how students are evaluated. The overlap of lab skills/activities between the Intermediate and Advanced lab courses will be also be discussed, including future plans for the physics major program of study.

PST2B25: 5-5:45 p.m. A Project-based Student Centered Approach to Second Semester Introductory Physics,

Poster – Mark F. Masters, IPFW, Department of Physics, Fort Wayne, IN

46805; masters@ipfw.edu

Jacob Millspaw, IPFW

Our continuous improvement/attempts at innovation in the introductory courses have led us to the use of projects in the class and Lab. Laboratory requires the students to build calorimeters and these were subsequently used in circuit investigations to collect quantitative data about parallel and series circuits. The lecture portion of the class makes extensive use of short investigations and ILD's. There are also a few projects in the class such as building a thermometer to determine absolute zero and a Stirling engine. These in class experiments engage the students in the material. The projects also force the students to build – for which we open our maker space – and demonstrate to engineering students that building something is not all following instructions.

Other Posters

PST2C01: 5-5:45 p.m. Engineering Design in a Physics Course for Future Elementary Teachers*

Poster – Yuri B. Piedrahita, Purdue University, 139 Airport Rd Apt 6, West Lafayette, IN 47906; ypiedrah@purdue.edu

Jeffrey W Murray, N. Sanjay Rebello, Purdue University

The Next Generation Science Standards (NGSS Lead States, 2013) and science standards of many states emphasize meaningful integration of practices of engineering and engineering design in K-12 science instruction. Most current courses that prepare K-12 teachers do not include integrated experiences for learning science. We describe an instructional unit that integrates learning of electric circuits in the context of an engineering design challenge in a physics course for future elementary teachers. We will describe the underlying framework and challenges of implementation. We also discuss the impact on student learning and refinement of their design. This effort is part of an NSF-funded project integrating engineering design experiences across multiple courses for pre-service elementary teachers. The project supports of one of the central goals of the Center for Advancing the Teaching and Learning of STEM (CATALYST) at Purdue University to positively impact the integration of STEM teaching and learning in K-12 classrooms.

*This work is supported in part by the U.S. National Science Foundation grant 1626197. Opinions expressed are those of the authors and not necessarily those of the Foundation.

PST2C02: 5:45-6:30 p.m. Effect of Cognitive Exam Wrappers on Student Metacognition Self-Monitoring

Poster – Patricia Soto, Creighton University, Creighton University, Omaha, NE 68178; patriciasoto@creighton.edu

Laura Aumen, Alexis Munchrath, Gintaras Duda, Creighton University

An extensive body of work establishes the critical importance of metacognition and reflection in the learning process. This work describes the implementation of a metacognitive intervention, a cognitive exam wrapper, to spur student thinking about their learning, their strategies for learning, and prompt them to identify and modify unsuccessful strategies for learning. Exam wrappers have been well received by our students and have proven valuable both to the instructors and the students. In our study, we tested to what extent exam wrappers influence student study habits, exam performance, and metacognitive skills development. Our analysis suggests that cognitive exam wrappers are especially effective when students are confronted with unfamiliar pedagogical modalities. We discuss the strengths and challenges in the use of exam wrappers and propose guidelines for the implementation of the tool in the classroom.

PST2C03: 5-5:45 p.m. Equity, Inclusion, and Cookies: Addressing Physics Climate Through Diversity Discussions

Poster – Katherine D. Rainey, CU Boulder, Department of Physics, Libby Drive, Boulder, CO 80305-5567; kara0871@colorado.edu

Joel C. Corbo, Nicole M. Simmons, CU Boulder

It is well known that women and people of color are largely underrepresented in physics at all levels, from undergraduates to faculty. A large body of literature has investigated the cause of this low representation; some work points to a "chilly" climate and unwelcoming culture within physics that is discouraging to women and people of color. In an effort to improve the culture within their department, a committee within the CU Boulder physics department has created Equity, Inclusion, and Cookies (EIC), a series of facilitated discussions and presentations related to diversity in physics open to everyone in the department (undergraduates, graduate students, postdocs, faculty, and staff). Here, we describe the EIC events to date, present initial reactions to these events from attendees, and discuss our plans for developing the series in the future.

PST2C04: 5-5:45 p.m. Effects of STEAM Program which Emphasizes Real World Phenomena

Poster – Eun Hee Kim, Seoul National University of Education, Seoul, Korea Seoul, 137-742 Korea; pw46ehkim@naver.com

The purpose of this study is to develop a STEAM program and analyze the effectiveness of it based on the core-competence, which is introduced in the 2015 revised Korean National Science Curriculum. The importance of observation is emphasized in this program, especially on the real world phenomena. The program was taught to students in Seoul, Korea. Throughout the program, their behaviors were examined to analyze their improvement on core-competences. As a result, the STEAM program gave positive influence on developing the core-competence. Especially, their scientific communication ability showed large improvement. since they had long time to discuss the phenomena. In addition, by observing real world phenomena, students attitude towards science has changed positively and showed improvement in life-long and scientific-participation competence. Based on the positive effects of the program, it would give good influences on developing teaching strategy which can develop students' core-competence.

Physics Education Research II

PST2D01: 5-5:45 p.m. A New 1-Semester Approach to Physics for Life Science Majors

Poster – Jason Puchalla, Princeton University Department of Physics, Jadwin Hall, Princeton, NJ 08544-1098; puchalla@princeton.edu

Isabelle Augensen, Morris High School

Kasey Wagoner, Princeton University

Nationwide, courses in physics for life science majors have undergone substantial changes in the past decade. A primary objective of these changes has been to increase life science "appeal" while not compromising on valuable learning goals. Achieving this objective is complicated by the need to serve students with a broad range of educational backgrounds (e.g. no background, AP credit, summer programs) and widely varying expectations (e.g. premedical preparation, course requirement for major, general interest in subject). Factors such as these coupled with ongoing modifications to medical school requirements have led us to investigate a survey-style, one-semester course intended to better meet the needs of students at Princeton University. Here we present the course structure, pedagogy and assessment results of the 2017 class offering. In this third offering, class enrollment reached capacity (45 + wait list) and included students from all life science departments.

PST2D02: 5:45-6:30 p.m. A Novel Approach for Using Programming Exercises in Electromagnetism Coursework

Poster – Chris Orban, The Ohio State University, 1465 Mt Vernon Ave., Marion, OH 43302-5628; orban@physics.osu.edu

Chris D. Porter, Nash Brecht, Joseph R. Smith, Demetrius Tuggle, The Ohio State University

Richelle Teeling-Smith, Marion Technical College / University of Mt. Union

While there exists a significant number of web interactives for introductory physics, students are almost never shown the computer code that generates these interactives even when the physics parts of these programs are relatively simple. Building off of a set of carefully designed classical mechanics programming exercises that were constructed with this goal in mind, we present a series of electromagnetism programming exercises in a browser-based framework called p5.js. Importantly, this framework can be used to highlight the physics aspects of an interactive simulation code while obscuring other details. This approach allows absolute beginner programmers to gain experience in modifying and running the program without becoming overwhelmed. We plan to probe the impact on student conceptual learning using the Brief Electricity and Magnetism Assessment and other questions. We invite collaborators and teachers to adopt this framework in their high school or early undergraduate classes.

PST2D03: 5-5:45 p.m. A Study on Online Learning Strategy and the Teaching-Learning Difficulties in Elementary School Science Class on the Chapter Titled "Magnet"

Poster – Jiye Kim, Changdong Seoul, Dobonggu 181-19, Republic of Korea; kjye29@hanmail.net

Youngseok Jhun

The purpose of this study is to survey and analyze the degree and also reasons of difficulties experienced by teachers and students in elementary school science class during the chapter titled "magnet." This study also attempts to investigate deeply and make it clear that there are major online learning strategies learners use within an actual online learning environment. Thus, positive effects for both students and teachers are expected if tangible magnet experiment contents within actual online learning environment that can overcome problem contents of actual magnet experiment are utilized. Therefore, in this study, tangible magnet experiment contents optimized at online learning have been established. And through major online learning strategies, we have observed a class using tangible magnet experiment contents, and analyzed the learning effect, and potential of magnet experiment has discussed.

PST2D04: 5:45-6:30 p.m. Addressing Student Ideas About Coordinate Systems in the Upper Division

Poster – Brian D. Farlow, North Dakota State University, Physics Department, NDSU, Dept. 2755 P.O. Box 6050, Fargo, ND 58108; brian.farlow@ndsu.edu

Warren Christensen, North Dakota State University

Marlene Vega, Michael Loverude, Cal State Fullerton

As part of a broader study on student thinking about mathematics in the undergraduate physics curriculum, we have developed instructional materials intended to promote productive student thinking about non-Cartesian unit and position vectors. Previous work has identified ideas that undergraduate physics students bring to bear while attempting to solve non-Cartesian coordinate system problems: resources for unit vectors, resources connecting polar vector elements to Cartesian vector elements, and the orthogonality of basis vectors in various coordinate systems. In previous studies, these resources are not always used productively, so these instructional materials seek to explicitly guide students to do so. We report on the development and pilot testing of this intervention among junior/senior-level undergraduate students.

PST2D06: 5:45-6:30 p.m. Analysis of Student Engagement with the Pulsar Search Collaboratory

Poster – Cabot Zabriskie, West Virginia University, 135 Willey Street, Morgantown, WV 26506-0002; cazabriskie@mix.wvu.edu

Kathryn Williamson John Stewart, West Virginia University

The Pulsar Search Collaboratory (PSC) is a project designed to inspire high school students to consider STEM careers by providing them with the opportunity to conduct actual scientific work analyzing radio astronomy data to discover pulsars. The activities of this project are conducted at multiple schools across the country and coordinated through a central web presence. In order to better understand how students are interfacing with the project, the students were given pre and post surveys as well as several "mini-surveys" to complete throughout their time in the program. Analysis of these surveys in addition to their website usage and pulsar scoring patterns was conducted to provide understand the relation of engagement in the program with development of STEM career intentions.

PST2D07: 5-5:45 p.m. Assessing the Implementation of Formative Feedback

Poster – Ashleigh N. Leary, Michigan State University 1310 BPS Physics Department, East Lansing, MI 48824-2320; learyash@msu.edu

Paul Irving, Danny Caballero, Michigan State University

Feedback is an essential part of student development, especially when it comes to working in groups and developing the skills that make group collaboration successful. Due to the increased emphasis on group-based learning and the appropriation of scientific practices, there is a greater importance placed on how an instructor delivers feedback. At MSU, in P^3, an introductory group based physics classroom, students are given feedback each week to encourage the development of scientific practices. The feedback focuses on highlighting positive and negative aspects of how their group is functioning and their individual contributions to the group. The negative elements work to notify students of what they need to work on and provide a strategy as to how, while the positive elements reassure the students of their strengths. This investigation examines the implementation of the positive/negative/strategy format by various instructors in the P^3 classroom.

PST2D09: 5-5:45 p.m. Attitudes of Pre-health Students Toward Reformed IPLS Course Materials*

Poster – Elliot E. Mylott, Portland State University, 1719 SW 10th Ave. Room 134, Portland, OR 97201; emylott@pdx.edu

Caitlin Kepple, Portland State University

Warren Christensen, North Dakota State University

Ralf Widenhorn, Portland State University

We developed modular multimedia educational material for a reformed pre-health focused IPLS course at Portland State University. The modules include videos of biomedical experts detailing the core physics behind devices in clinical use. Original text and online homework problems expand on the material presented by the biomedical experts. Our research on the course explored (1) whether students' opinions on the relevance of physics to medicine was impacted by the biomedical focused physics instruction and (2) how that influenced their interest in physics. Shifts in attitudes were collected through student surveys in both the reformed IPLS course and a concurrent traditional course. Interviews from students in the IPLS course were used to elucidate responses from the surveys.

*This work was supported by a grant (DUE-1431447) from the National Science Foundation.

PST2D10: 5:45-6:30 p.m. Belongingness, Student Anxiety, and Student Performance

Poster – Todd Zimmerman, University of Wisconsin - Stout, 410 10th Ave. E, Menomonie, WI 54751; zimmermant@uwstout.edu

Laura Schmidt, Matt Corne, University of Wisconsin - Stout

A belongingness activity was implemented in introductory-level math and physics courses. In our investigation, we gave students a series of quotes from previous students about how they coped with not feeling like they belonged and then asked the current students to write a short description of how they are dealing with their feelings of belonging in their course. We looked at whether this intervention had an impact on student anxieties associated with the class and their sense of belongingness. We also looked at how the belongingness intervention affected student performance in the classes. We will discuss our initial findings and future directions.

PST2D11: 5-5:45 p.m. BLiSS Physics: A Studio Physics Course for Life Science Students

Poster – Vashti A. Sawtelle, 567 Wilson Rd., East Lansing, MI 48824-

2320; vashti.sawtelle@gmail.com

Katie Hinko, Michigan State University

Introductory Physics for the Life Sciences (IPLS) courses are gaining momentum in the physics education community, with the creation of multiple curricula for a variety of implementation strategies. At Michigan State University, we have designed an integrated lab-lecture (studio style) introductory physics course that meets the needs of life science students. Our design of this course focused on (1) connecting the disciplines of physics, biology, and chemistry through designing authentic tasks for students in collaboration with biophysicists, (2) incorporating computational simulations that model complex biological phenomenon, and (3) building positive relationships for life science students with physics. This poster will describe our overarching approach to the design of this course, share example curricular materials for manifesting these design goals in the classroom and describe some of the ongoing research on this course.

PST2D12: 5:45-6:30 p.m. Building Success; Designing for Growth in DATA Lab*

Poster – William M. Martinez, Michigan State University, 1310B BPS Building, East Lansing, MI 48824; marti790@msu.edu

Marcos D. Caballero, Michigan State University

Since the development of the AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum, curriculum design in laboratory courses has been increasingly focused on developing experimental skills and practices. Although many laboratory transformations share the same goal, the structures and supports within the course differ vastly. A newly transformed introductory physics lab curriculum at Michigan State University, Design, Analysis, Tools, and Apprenticeship (DATA) Lab, has been designed to emphasize growth in a student's experimental skills. In this poster, specific course structures that provide opportunities and support leading to students success will be highlighted.

*This work is funded by a Howard Hughes Medical Institute Science Education Grant

PST2D13: 5-5:45 p.m. Case Study: Teaching Method Improvements Measured by FCI

Poster – Michael Dolan, St. Andrew's Episcopal School, 5901 Southwest Pkwy., Austin, TX 78735; mdolan@socraticbrain.org

Richard Wright, St. Andrew's Episcopal School

This Case Study analyzes the impact of five HS teaching methods listed below. It includes FCI scores to measure learning outcome improvements. 1. Pedagogie - Interactive engagement / Modeling Instruction 2. Assessment - Mastery / standard based grading 3. Classroom - Standing tables and rolling whiteboards (no desks or chairs) 4. Textbook - Customized course-pac (combines worksheets, labs, readings, and a graphing notebook) students add content. 5. Technology - Graphing (Logger Pro / Desmos); skills practice and assessment (Socratic Brain), document workflow (Google Classroom) The three-year study includes one hundred 10th grade students per year, learning introductory physics with three teachers and seven classes.

https://www.sasaustin.org/page http://www.socraticbrain.org/

PST2D14: 5:45-6:30 p.m. Catalyzing Sustained Transformations in a Large Enrollment Introductory Electromag netism Course

Poster – Charles M. Ruggieri, Rutgers, The State University of New Jersey, 136 Frelinghuysen Road, Piscataway, NJ 08854; chazr@physics.rutgers.edu

Suzanne White Brahmia, University of Washington

Large enrollment physics courses for engineers at Rutgers include many components, with teams of faculty responsible for content. Course administrators change every few years and often modify materials based on their experiences, degrading improvements from a given year after few iterations.[1] To address these issues, we initiated the Measurable Learning Objectives Project, which has informed the transformation of a large enrollment calculus-based electricity and magnetism course. Faculty and PER researchers collaborated to construct measurable objectives based on published goals from several sources[2-4] and coupled objectives to a form of assessment. We categorized topics from the prior year's course and extracted weekly learning objectives, used existing assessments to evaluate if the component satisfies the objectives, and used the results to influence modifications of content emphasis and method. We address learning objective development and collaborative efforts to improve course materials.

[1] Henderson (2007) [2] Pollock (2009) [3] Deslauriers (2009) [4] Beichner (2016)

PST2D16: 5:45-6:30 p.m. Characterizing Practices and Resources for Inclusive Physics Learning Environments*

Poster – Laura A. Wood,** Seattle Pacific University, 3307 3rd Ave. W, Seattle, WA 98119; woodl5@spu.edu

Amy D. Robertson, Seattle Pacific University

Fostering inclusive physics learning environments is an important aspect of improving physics culture and teaching. In this project, we interviewed physics faculty who are actively working to make their classrooms and departments more inclusive. We characterized the inclusive practices these faculty described and the resources – e.g., the knowledge, dispositions, commitments, etc. – that fuel or support them. This talk will give examples of these resources and practices for inclusive physics learning, illustrating both the breadth and richness of resources physics faculty are using and the ways in which those resources are enacted in teaching strategies and departmental actions.

*This work is supported in part by NSF DUE 1611318. **Sponsored by Amy D. Robertson

PST2D18: 5:45-6:30 p.m. Comparison of Student Interaction Patterns with and Without Learning Assistants

Poster – Jiwon Lee, Korea National University of Education, 427 science building, KNUE, 250 Taesungtapyeonro, Cheongju , Chungbuk 28173 South Korea; ljiwony@naver.com

Jinwoo Mo, Jungbog Kim, Korea National University of Education

This study investigated observed differences in the interaction patterns of students in peer discussions according to the involvement of learning assistants. It examined further the effect of such differences on the mental models of students. Two separate classes consisting of 30 students each, and each class equally divided into 10 teams, were conducted utilizing peer discussions. One class had learning assistants while the other has none. After the collection and analysis of the recordings of the discussion process and three types of test results, pre-, post-, and delayed-test, it was revealed that the group with learning assistants mainly consented when the answers of peers were the same.

PST2D19: 5-5:45 p.m. Correlation Between Physics Learning Attitude and Motivation of College Students

Poster – Shihong Ma, Department of Physics, Fudan University, 220 Handan Road, Shanghai, SH 200433 China; shma@fudan.edu.cn

Siqi Wang, Department of Physics, Fudan University

In the past, physics education research only contained learning attitude, and did not involve learning motivation. In this paper, by using self-designed questionnaire, we investigate some students in Fudan University to study the correlation between attitude and motivation of physics learning, and give some suggestions for College Physics Teaching. It was found that there is a strong positive correlation relationship between college students' learning attitude and motivation. The both was significantly associated at the 0.01 level, the correlation coefficient of was 0.592.

PST2D20: 5:45-6:30 p.m. Developing and Evaluating a Tutorial on the Double-Slit Experiment

Poster – Ryan T. Sayer, Bemidji State University, 1407 Beltrami Ave NW, Bemidji, MN 56601; rsayer@bemidjistate.edu

Alexandru Maries, Chandralekha Singh, University of Pittsburgh

Learning quantum mechanics is challenging, even for upper-level undergraduate and graduate students. Interactive tutorials that build on students' prior knowledge can be useful tools to enhance student learning. We have been investigating student difficulties with the quantum mechanics pertaining to the double-slit experiment in various situations. Here we discuss the development and evaluation of a Quantum Interactive Learning Tutorial (QuILT) which makes use of an interactive simulation to improve student understanding. We summarize common difficulties and discuss the extent to which the QuILT is effective in addressing them in two types of physics courses. We thank the National Science Foundation for their support.

PST2D21: 5-5:45 p.m. Developing and Validating a Conceptual Survey to Assess Student Understanding of Thermodynamic Processes and First and Second Laws

Poster – Chandralekha Singh University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; clsingh@pitt.edu

Benjamin Brown, University of Pittsburgh

We discuss the development and validation of a conceptual multiple-choice survey called the Survey of Thermodynamic Processes and First and Second Laws (STPFaSL) suitable for introductory physics courses. The survey was developed taking into account common student difficulties with these concepts in that the incorrect choices to the multiple-choice questions were designed based upon the common difficulties. After the development and validation of the survey, it was administered to introductory physics students in various classes in paper-pencil format before and after traditional lecture-based instruction in relevant concepts. We compared the performance of students on the survey in introductory physics courses before and after traditional lecture-based instruction in relevant concepts. We also administered the survey to upper-level undergraduates majoring in physics and PhD students to benchmark the survey and compared their performance with those of students in traditionally taught introductory physics courses for whom the survey is intended. We find that although the survey is focused on thermodynamics concepts covered in introductory courses, it is challenging even for advanced students.

PST2D22: 5:45-6:30 p.m. Developing Items for Physics Identity Survey Applied to Laboratory Settings

Poster – Kelsey M. Funkhouser, Michigan State University, 567 Wilson Road, East Lansing, MI 48824-2320; kfunkh@msu.edu

Vashti Sawtelle, Marcos D. Caballero, Michigan State University

There is an abundance of work showing that students generally do not have positive views of physics, or see themselves as part of physics. Physics lecture courses can make those views even worse. One tool for improving student experiences is to engage students in authentic science practices. Laboratory courses are intended to be an opportunity for students to engage in activities that reflect the practices of a physicist. We are developing a survey that can be used to systematically determine students' views toward physics and where they position themselves with respect to physics (physics identity). Using the communities of practice framework, we are designing a study to measure how students' physics identities are affected by physics laboratory courses. We will be presenting on the development of items for the survey through student interviews and classroom observations.

PST2D24: 5:45-6:30 p.m. Do Assessments Engage Students in Scientific Practices?

Poster – Katherine C. Ventura, Kansas State University, 1228 N. 17th St., Manhattan, KS 66506-2601; katventura@ksu.edu

James T. Laverty, Kansas State University

Recent national reports have elevated learning how to do physics to the same level as learning the concepts of physics. "Scientific practices" are designed to shift the focus of physics education to a student's ability to do science in addition to their content knowledge. Assessing these practices is important in determining if we, as educators, are facilitating the student's ability to engage in the process of science. The recently released Three-Dimensional Learning Assessment Protocol (3D-LAP) was developed to characterize assessment tasks that have the potential to elicit evidence that students have learned scientific practices. We are developing tasks aligning with scientific practices. We will interview students working on those tasks using a think-aloud protocol and analyze the interviews to find evidence that students are (or are not) engaging in scientific practices. This observation will inform how well we are able to assess the scientific practices we want students to learn.

PST2D25: 5-5:45 p.m. Do Post-lecture Quizzes Act as Motivating Factor for Students' Success?

Poster – Joshua Howell, Columbia State Community College, 4650 Peytonsville Rd., Columbia, TN 38401; jhowell29@columbiastate.edu

Binod Nainabasti, Columbia State Community College

Have you ever had experience in a classroom where some of your students were not paying attention? Thinking about the due date of another homework? Having private conversations with neighbors? Hiding and texting? The purpose of this paper is to report the results of an investigation on the impact of post-lecture quizzes on students' level of attentiveness in classrooms and how quizzes scores associate with their success through the course. Daily classroom quizzes of three to five multiple-choice questions from six different introductory science classes, students' self-reported data on how classroom quizzes motivated them to be more attentive, and students' exam score in the courses have been utilized for the investigation. Our preliminary results suggest that when scores on post-lecture quizzes are included in the final grade then quizzes scores are more positively associated with their final exam score than when quizzes scores are considered only as extra credit for final grade.

PST2D26: 5:45-6:30 p.m. Effect of Presentation Language on Uncertainty Comprehension and Attitudes

Poster – Michelle Milne, St. Mary's College of Maryland, 47645 College Drive, St. Mary's City, MD 20686-3001; mlmilne@smcm.edu

Measurement uncertainty concepts were presented to two first-semester introductory physics laboratory sections in different languages. Uncertainty concepts were presented to one section couched in standard uncertainty of measurement language while the concepts were presented to the other section couched in terms of certainty of measurement language. To gauge the effect of the two variations of presentation, student assignments were scored for mastery of uncertainty concepts and students filled out a Likert attitude survey at several points during and after the semester. No significant difference in abilities was found between the two populations, but there was a difference in the evolution of attitudes towards uncertainty between the two populations, with the "certainty" language population showing a decrease in agreement with expert attitudes.

PST2D27: 5-5:45 p.m. Effect of Supplementary Videos on Scientific Reasoning in a General-Physics Course

Poster – Amber R. Sammons, Illinois State University, 2006 Kaskaskia Drive, Springfield, IL 62702; arsamm1@ilstu.edu

Jessica Tolmie, Illinois State University

Terry-Ann Sneed, Heartland Community College

Reggie Dizon, Raymond Zich, Illinois State University

This study investigated the impact of an instructional reform on student scientific reasoning skills and general attitudes toward science. The intervention was administered via nine 5-7 minute videos during lab. Each video consisted of an explanation of its targeted concept, a hands-on demo with observations and YouTube clips highlighting the topic being discussed. While viewing the videos, students were required to answer specific questions testing their comprehension of the concepts and scientific reasoning being displayed. Students indicated they enjoyed the videos. Lawson's Scientific Reasoning Test was administered to assess improvement in student scientific reasoning skills, and the CLASS was used to assess changes in student attitudes towards science. Pre- and post-test results are compared for a control semester and a semester with this new teaching method.

PST2D28: 5:45-6:30 p.m. Energy Quantization: Student Understanding of Quantum Mechanics in Chemistry

Poster – Adam T. Quaal, California State University, Fullerton, 800 North State College Blvd., Fullerton, CA 92834; adam.quaal@csu.fullerton.edu

Misael Calleja, Gina Passante, California State University, Fullerton

While undergraduate physics students encounter quantum mechanics (QM) topics towards the end of their introductory courses, introductory chemistry courses often teach QM concepts earlier in the context of electron orbitals and transitions. Student understanding of atomic energy levels is of particular interest from a physics education perspective, as this concept can provide a bridge from general chemistry to an upper-division physics QM course. In this work, we analyze student responses to QM assessment items given during an introductory general chemistry course. Specifically, we focus on the concepts of energy levels and quantization, as well as the relationship between energy level diagrams and atomic spectra.

PST2D29: 5-5:45 p.m. Examining the Effects of Testwiseness Using the FCI and CSEM

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; stdevore@mail.wvu.edu

John Stewart, West Virginia University

Testwiseness is generally defined as the set of cognitive strategies used by a student and intended to improve their score on a test regardless of the test's subject matter. To improve our understanding of the potential effect size of several well-documented elements of testwiseness we analyze student performance on questions present in the Force Concept Inventory (FCI) and Conceptual Survey on Electricity and Magnetism that contain distractors, the selection of which can be related to the use of testwiseness strategies. Additionally, we examine the effects of the position of a distractor on its likelihood to be selected in 5-option multiple choice questions. We further examine the potential effects of several elements of testwiseness on student scores by developing two modified versions of the FCI designed to include additional elements related to testwiseness. Details of the effect sizes of these various aspects of testwiseness will be discussed.

PST2D30: 5:45-6:30 p.m. Examining the Role of Context in Student Reasoning*

Poster – Mila Kryjevskaia, North Dakota State University, Department of Physics, PO Box 6050, Fargo, ND 58108-6050; mila.kryjevskaia@ndsu.edu

Cody Gette, North Dakota State University

J. Caleb Speirs, MacKenzie R. Stetzer, University of Maine

As part of an ongoing investigation of student reasoning, we have been developing and refining methodologies that allow for the identification of specific factors that tend to enhance or suppress student reasoning abilities. This poster focuses on the role of context in student reasoning. Sets of isomorphic questions were developed in multiple contexts (e.g., rotational kinematics and capacitance). Each question in the set requires students to apply the same line of reasoning in order to arrive at a correct answer. The identified reasoning patterns appear to be largely context dependent. In particular, students were more likely to abandon formal lines of reasoning in favor of more intuitively appealing arguments in some contexts, but not in others. Data from multiple question sets will be presented and instructional implications will be discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, DUE-1431541, DUE-1431940, DUE-1432052, DUE-1432765.

PST2D31: 5-5:45 p.m. Examining the Role of Insight in Student Reasoning*

Poster – Cody Gette, North Dakota State University, 218 South Engineering, 1211 Albrecht Blvd., Fargo, ND 58108; cody.gette@ndsu.edu

Mila Kryjevskaia, North Dakota State University

Many students fail to arrive at a correct solution to a given problem even though they possess the required knowledge and skills to do so. We aim to identify cognitive mechanisms that may account for the observed reasoning patterns. In some cases, an unproductive heuristic representation of a problem may lead to a mental impasse. To break the impasse, the problem representation may need to be changed. This mental change to a more productive representation is known as "insight". This switch often results in a fast, immediate solution (an "Aha!" moment). It does not stem from gaining additional knowledge and is rather due to a change in the reasoner's initial heuristic model. The relevance of insight to physics learning will be illustrated in multiple contexts. Instructional implications will be discussed.

*This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1431857, 1431541, 1431940, 1432052, 1432765.

PST2D32: 5:45-6:30 p.m. Expanding the PICUP Community of Practice

Poster – Paul W. Irving, Michigan State University, 1310D Biomedical and Physical Sciences Building, East Lansing, MI 48823; paul.w.irving@gmail.com

Marcos D. Caballero, Michigan State University

The mission of the Partnership for Integration of Computation into Undergraduate Physics (PICUP) is to expand the role of computation in the undergraduate physics curriculum. A major effort to facilitate this expansion is the PICUP Faculty Development Workshop (FDW), which functions in a similar way to the New Faculty Workshop. FDW invitees engage and learn about educational practices associated with integrating computation into their curriculum designs. With this focus on community building and engagement in the legitimate peripheral practices of the PICUP community, we have developed a project that applies the communities of practice framework to understand how the PICUP community develops over time. Presented in this poster are the initial stages of this work which contrasts the perceptions and experiences of attendees of the PICUP workshop (peripheral members of the community) with those of the central members of the PICUP community (workshop organizers).

PST2D33: 5-5:45 p.m. Experimentally based Mechanics Tutorials: Results for Students with Varying Preparation

Poster – Laura J. Tucker, University of California, Irvine, 4129 Frederick Reines Hall, Irvine, CA 92697-4575; tucker@uci.edu

Franklin Dollar, University of California, Irvine

The introductory Newtonian mechanics course is one of the largest barriers in an undergraduate physics program. The Washington Tutorials have been repeatedly shown to increase students' conceptual mechanics understanding. Building on this format in an effort to improve student performance, we reformed the two-hour weekly laboratory component of our large-enrollment introductory mechanics course with three primary goals: use hands-on experiments, encourage in-depth conceptual discussions, and tailor to students of varying preparation. With the implemented curriculum, we show conceptual gain results for student populations with different levels of incoming preparation. We also present data on student satisfaction in response to this approach.

PST2D34: 5:45-6:30 p.m. Exploring Student Communities in Group Exam Settings

Poster – Steven F. Wolf, East Carolina University, Department of Physics, Greenville, NC 27858-4353; wolfs15@ecu.edu

Timothy Sault, East Carolina University Depertment of Physics

Cody Blakeney, Hunter G. Close, Texas State University

Collaboration is an integral part of science, and as our classrooms

become more collaborative, so to can our assessments. Group exam data gives us a new kind of data about how our students relate to each other. Network analysis provides many tools for describing, visualizing, and analyzing student networks. In particular, we are interested in probing many different aspects of these communities. For example, how does network position relate to content knowledge? And can we track how ideas flow through a class?

PST2D36: 5:45-6:30 p.m. The Physics Lab Inventory of Critical Thinking

Poster – Katherine Quinn, Cornell University, 315 – 142 Sciences Dr., Ithaca, NY 14853; knq2@cornell.edu

Natasha G. Holmes, Cornell University

Carl Wieman, Stanford University

In this poster, we will present the Physics Lab Inventory for Critical thinking (PLIC), a closed-response assessment to evaluate physics lab courses. It is aimed to assess the efficacy of lab courses at developing critical thinking as related to making sense of experiments, data, variability, and models. We will present the assessment motivation, development and validation, and preliminary results.

PST2D37: 5-5:45 p.m. Theoretical Framework for Helping Students Engage with Self-Paced Learning Tools

Poster – Emily M. Marshman, University of Pittsburgh, 209 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Seth DeVore, West Virginia University

Chandralekha Singh, University of Pittsburgh

As research-based, self-paced e-learning tools become increasingly available, a critical issue educators encounter is implementing strategies to ensure that all students engage with them as intended. Here, we first discuss the effectiveness of research-based e-learning tutorials as self-paced learning tools in large enrollment brick and mortar introductory physics courses and then propose a framework for helping students engage effectively with self-paced learning tools. Instructors encouraged the use of these self-paced tools in a self-paced learning environment by telling students that they would be helpful for solving the assigned homework problems and that the underlying physics principles in the tutorial problems would be similar to those in the in-class quizzes (which we call paired problems). We find that many students, who struggled in the courses in which these interactive e-learning tutorials were assigned as a self-study tool, performed poorly on the paired problems. In contrast, a majority of student volunteers in one-on-one implementation performed well on the paired problems. We propose a theoretical framework to help students with diverse prior preparations engage effectively with self-paced learning tools. We thank the National Science Foundation for support.

PST2D38: 5:45-6:30 p.m. Towards Defining Productivity in Informal Physics Education Programs

Poster – Michael B Bennett, JILA Physics Frontier Center and University of Colorado Boulder, Boulder, CO 80303; michael.bennett@colorado.edu*

Claudia Fracchiolla, University of Colorado Boulder

Kathleen A. Hinko, Michigan State University

Brett Fiedler, Noah D. Finkelstein, University of Colorado Boulderr

Informal education programs provide a unique opportunity to study student learning, since participating students are usually involved by choice and because the activities that students engage in are largely of their own choosing. Students may additionally come into the program with different objectives and conceptions of the program's purpose, which may manifest in their behavior. In PISEC (Partnerships for Informal Science Education in the Community), a CU Boulder-affiliated informal physics education program, students in grades K-8 meet once per week with CU mentors to engage in hands-on physics activities in an afterschool setting. PISEC provides opportunities to observe students in practice and to study both stated and enacted student objectives. We observed students over a semester and conducted end-of-semester interviews to obtain data on their behavior and stated objectives in PISEC. We discuss preliminary findings and note instances where students' actions and reflections appear to be in coordination or discoordination.

*Sponsored by Noah D. Finkelstein

PST2D39: 5-5:45 p.m. Understanding Measurement and Uncertainty in a Large Introductory Laboratory Course

Poster – Benjamin Pollard, University of Colorado Boulder, Department of Physics, 390 UCB Boulder, Boulder, CO 80303; Benjamin.Pollard@colorado.edu

Jacob T. Stanley, Robert Hobbs, Dimitri R. Dounas-Frazer, Heather J. Lewandowski, University of Colorado Boulder

Physics laboratory courses form an essential part of physics undergraduate curricula. Learning goals for these classes often include the ability to interpret measurements and uncertainties. The Physics Measurement Questionnaire (PMQ) is an established open-response survey probing students' understanding of measurement uncertainty. It classifies students' reasoning into point and set paradigms, with the set paradigm more aligned with expert reasoning. Point-like reasoning makes conclusions directly from individual data points, with deviations attributed to environmental factors or mistakes. In the context of a course transformation effort at the University of Colorado, we examine over 600 student responses to the PMQ both before and after instruction. We describe changes in students' understanding and identify areas for future investigation.

PST2D40: 5:45-6:30 p.m. Understanding Student Perceptions of Computational Physics Problems in Introductory Mechanics

Poster – Nathaniel T. Hawkins, Michigan State University, 567 Wilson Road, 1310 BPS, East Lansing, MI 48824-2320; hawki235@msu.edu

Marcos D. Caballero, Paul W. Irving, Michigan State University

Projects and Practices in Physics ("P-Cubed") is a transformed, first-year introductory mechanics course offered at Michigan State University. The focus of the course is concept-based group learning implemented through solving analytic problems and computational modeling problems using the programming language VPython. Interviews with students from P-Cubed were conducted to explore the variation of students' perceptions of the utility of solving computational Physics problems as it relates to their learning of Physics. A phenomenographic method is being used to develop categories of student experience with computational Physics problems. The focus of this presentation is to display interview data and discuss the recurring themes we have seen in these interviews.

PST2D41: 5-5:45 p.m. Understanding the Origins of Teachers' Resources for Accelerated Motion*

*Poster – Elijah Tabachnick,** University of Maine, 5709 Bennett Hall, Orono, ME 04469-5709; elijah.tabachnick@maine.edu*

Peter Colesworthy, Michael C. Wittmann, University of Maine

In the "speed model" of accelerated motion, the terms "speeding up" and "slowing down" are equated with positive and negative acceleration, respectively. As part of the Maine Physical Sciences Partnership, we have investigated middle school physical science teachers' understanding of accelerated motion in the context of using vectors as a pictorial tool for kinematics and found a high prevalence of the speed model. Through observation of professional development activities, interviews, and surveys, we have found that the teachers consistently use the correct mathematical tools to talk about displacements and velocities, and correctly use vectors to represent displacements, velocities and accelerations. However, when interpreting the acceleration of an object, teachers often use the speed model, which contradicts their other work. We discuss this result and its possible origin, including the idea of subtraction ("minus") from the magnitude being equated with the speed change ("negative") in the acceleration.

*Supported in part by NSF MSP 0962805. **Sponsored by Michael Wittmann.

PST2D42: 5:45-6:30 p.m. Using Eye Tracking to Differentiate Student Difficulties Reasoning with Data

Poster – Raymond Zich, Illinois State University, Physics Department Campus Box 4560, Normal, IL 61790; rlzich@ilstu.edu

Rebecca Rosenblatt, Illinois State University

Findings from a past project studying students in algebra-based physics courses indicate significant issues working with graphed and pictured data. Students overuse reasoning schemes that work for one cause – one effect data but do not work for multiple causes. Students make incorrect claims like, "If variable A is unchanged and variable B does change than variable A must not affect variable B." In this study, we use eye tracking data to investigate students' attention to the variables in the graphs and pictures. We observe different student gaze patterns on questions answered incorrectly vs. correctly. This demonstrates that control-of-variables (and not just logical reasoning) affects student skills with data interpretation. In addition, we present other results. For example, students who are correct show relatively more time (as a percentage of each persons' gaze time) attending to the legend in a graph, the unchanged – i.e. controlled for – variable, and the effect variable.

PST2D44: 5:45-6:30 p.m. Vector Angular Displacement

Poster – William A. Dittrich, Portland Community College, PO Box19000 Portland, OR 97219; tdittric@pcc.edu

Leonid Minkin, Robert Drosd, PCC

Alexander Shapavolov, Saratov State University, Russia

A new way to teach rotational dynamics whereby angular displacement is correctly defined as a free axial vector is described in this poster. This method of teaching rotation greatly improves rotational theory in that it makes rotational and translational pedagogy completely symmetrical and consistent with one another.

PST2D45: 5-5:45 p.m. What Does Mathematical Sense-Making Look Like in Quantum Mechanics?

Poster – Jessica R. Hoehn, University of Colorado Boulder, 390 UCB, Boulder, CO 80309; jessica.hoehn@colorado.edu

Julian Gifford, Noah D. Finkelstein, University of Colorado Boulder

Erin Ronayne Sohr, Ayush Gupta, University of Maryland

Integrating mathematical formalism and conceptual understanding is an essential part of learning physics. However, it can be tempting, in physics learning and in instruction, to just "plug and chug" through the math and leave the sense-making for later, or to assume that meaning comes along for the ride with algorithmic proficiency. We focus on the domain of quantum mechanics and investigate how we can help students to engage in mathematical sense-making, broadly defined as seeking coherence between mathematical formalism and conceptual reasoning while manipulating mathematical systems (e.g. equations or graphs). In this interactive poster, we present preliminary curricular materials geared towards supporting mathematical sense-making in quantum mechanics, and seek input from members of the physics education community around both the content and approach for a mathematical sense-making rich quantum mechanics curriculum.

PST2D46: 5:45-6:30 p.m. Why Pop Culture May be Important for Learning Physics

Poster – Kathleen A. Hinko, Michigan State University, 919 E. Shaw Ln., East Lansing, MI 48825; hinko@msu.edu

Claudia Fracchiolla, University of Colorado Boulder

Student engagement is critical to learning, especially in environments designed to encourage student agency. We investigate student engagement in an after-school physics program for K-12 students facilitated by students from the University of Colorado Boulder. Using an activity theory framework, we analyze videos from the interactions of children in small groups during afterschool sessions. Through activity theory analysis we are able to identify group dynamics that contribute to or hinder individual student engagement in informal learning environments. We present data from student groups that seem to facilitators to struggle to stay "on task". However, we find that students' social engagement with peers is not binary with their scientific engagement with the activities. Rather, these dual ways of engaging can support students' objectives in the program. We also find that through mediation, differences between these dimensions (social vs science engagement) can realign the activity systems so that participants can productively participate.

PST2D47: 5-5:45 p.m. Design and Assessment of the Electron Gas Model

Poster – Jan-Philipp Burde, Goethe-Universität Frankfurt, Department of Physics Education Research, Max-von-Laue-Str.1 Frankfurt am Main, Hessen 60438 Germany; burde@physik.uni-frankfurt.de

Thomas Wilhelm, Goethe-Universität Frankfurt

Research has shown that most students do not succeed in developing a robust understanding of voltage or potential. Instead students tend to reason exclusively with current and resistance when analyzing electric circuits. The idea of the electron gas model is to give students a strong qualitative conception of the electric potential by comparing it with air pressure. Voltage as electric pressure difference is then introduced as the causal agent of current propulsion just as air pressure differences are the cause of air flow (e.g. bicycle tires). Similarly, the concept of electric resistance is introduced in analogy to a dense fabric cushion impeding the airflow. The teaching concept has proven to be effective in a study with more than 700 students based on a pre-test-post-test-control-group-design. The poster will illustrate key ideas of the concept and highlight key findings of the multiple-choice diagnostic assessment.

PST2D48: 5:45-6:30 p.m. Examining Student Attitudes via the Math Attitude and Expectations Survey

Poster – Deborah Hemingway, University of Maryland, College Park, 3103 River Bend Ct #A101, Laurel, MD 20724; deb.hemingway@gmail.com

Mark Eichenlaub, Edward F. Redish, University of Maryland, College Park

The Math Attitude and Expectations Survey (MAX) is one of two novel assessment surveys developed as part of a mixed-methods exploratory project that seeks to understand and overcome the barriers that students face when using math in science. The MAX is a 30-question Likert-scale survey that focuses on student attitudes towards using mathematics in a reformed Introductory Physics for the Life Sciences (IPLS) course, part of the National Experiment in Undergraduate Education (NEXUS/Physics) project. Survey development and results are discussed with specific attention given to students' attitudes towards math and physics, opinions about interdisciplinarity, and the usefulness of physics in academic settings as well as in professional biological research and modern medicine settings. We also utilized the outcomes of the second novel assessment survey, the Mathematical Epistemic Games Survey (MEGS), to gain further insight into and compare results of this survey across multiple institutions.'

PST2D49: 5-5:45 p.m. Distinguishing Between Total Force and Net Force – Students' Embodied Simulations

Poster – Philip B. Southey, University of Cape Town, Rondebosch, Cape Town, WC 7700 South Africa; philsouthey@gmail.com

Saalih Allie University of Cape Town

"Two forces are applied to a box. Force 1 has a magnitude of 4 N and acts East, while force 2 has a magnitude of 4 N and acts West. What is the total force applied to the box?" The two most common answers to this question are 0 N (correct) and 8 N (incorrect). We shall argue that one of the reasons students answer this question incorrectly is because of the word "total." The terms "net force," "resultant force," and "total force" are used interchangeably in physics textbooks. However, we have found evidence to suggest that students readily distinguish between the notions of "total force" and "net force" (or "resultant force"). One of the ways they draw this distinction is by creating two different simulations (ala Barsalou); one which focuses on the "felt experience" of the box, and the other which focuses on the box's resultant motion.

PST2D50: 5:45-6:30 p.m. Gateways ND: Investigating Student Perceptions of Office Hours*

Poster – Alistair G. McInerny, North Dakota State University, 1340 Administration Ave., Fargo, ND 58102; Alistair@Mcinerny.org

Tuesday afternoon

Mila Kryjevskaia, Jared Ladbury, Paul Kelter, North Dakota State University

As part of a campus-wide initiative to improve teaching and learning at North Dakota State University, we are investigating student and faculty use and perceptions of office hours. We apply the Theory of Planned Behavior as a framework for the development of a survey designed to gain insights into students' intentions to utilize office hours. We examine three factors that may impact student intentions: attitudes towards office hours, norms regarding office hours, and control beliefs about office hours. Analysis of more than 400 survey responses indicates that student intentions are primarily linked to student attitudes towards office hours, while no significant link is identified between intentions, norms, and control beliefs.

*This material is based upon work supported by the National Science Foundation under Grant No. DUE-1525056.

PST2D51: 5-5:45 p.m. Characterizing Active Learning Tasks in University Science Classrooms

Poster – Leanne Doughty, University of Colorado Denver, 610-B Lawrence Street Center, 1380 Lawrence St., Denver, CO 80202; leanne.doughty@ucdenver.edu

Robert M Talbot, Laurel Hartley, Amreen Nasim, Paul Le, University of Colorado Denver

There is strong evidence that the implementation of active learning in undergraduate science courses can lead to increased student conceptual understanding and course achievement, but we still do not know what specific characteristics of active learning contribute the most to student success. Our work examines the tasks that students are asked to engage with during active learning, with the ultimate goal being to look at the relationship between different task characteristics and different student level outcomes (e.g., concept inventory gains, course achievement, retention, and persistence). To this end, we are working to characterize the active learning tasks that students engage with in the classroom with respect to authenticity, cognitive depth, and alignment with course objectives and assessment measures. We will present our characterization of the tasks we have collected from introductory physics, chemistry and biology courses, and discuss the relationship between these different characteristics and student level outcomes.

PST2D52: 5:45-6:30 p.m. Psychometric analysis of the Force Concept Inventory (FCI) gender fairness

Poster – Rebecca Lindell Tiliadal STEM Education Lafayette, IN 47901

John Stewart, Gay Stewart, West Virginia University

Adrienne Traxler. Wright State University

Alexis Papak, University of Maryland

To investigate the well-documented difference between male and female students' performance on the Force Concept Inventory (FCI), we studied samples from four different universities' calculus-based physics mechanics courses. Unlike most previous psychometric studies of the FCI, we separated the female from the male students, as the male students outnumbered female students 4:1 for each sample. Using classical and modern test theory, we found that more than half the test items are poorly functioning in terms of difficulty or discrimination measures, and five items have anomalously high difficulty for female students across samples. Notably, most of these items were not flagged when the dataset was aggregated across genders. In addition, we examined item bias utilizing Differential Item Functioning and identified a total of eight biased items, with six items biased toward men and two items toward women. Eliminating the poorly functioning/ biased items substantially reduces the gender difference in scores.

PST2D53: 5-5:45 p.m. Using PhET Simulations to Teach Students How to Create Meaningful Contrasting Cases

Poster – Jonathan Massey-Allard, University of British Columbia, 2329 West Mall, Vancouver, BC V6T 1Z4 Canada; jmassall@phas.ubc.ca

Joss Ives, Ido Roll, University of British Columbia

Recent work on inquiry activities in open-ended physics virtual labs (such as PhET simulations) suggest that students that create contrasting experiments in a deliberate fashion achieve better learning outcomes.[1] This is particularly interesting considering that the process of explaining different contrasting instances of a physics phenomenon (so-called "contrasting cases") have been shown to help students achieve a more profound understanding of the underlying structure behind the phenomenon.[2] This leads to the question of whether or not such a compare and contrast approach in the context of a virtual lab can be taught in a classroom setting. Here, we discuss an approach whereby students learn to create their own contrasting cases through a series of short learning by teaching activities based on different PhET simulations.

1. Bumbacher, et. al., International Educational Data Mining Society (2015);
2. Shemwell, et. al., J Res Sci Teach, 52: 58–83 (2015).

PST2D54: 5:45-6:30 p.m. Attitudes in Introductory Physics for Life Science and Engineering Students

Poster – Max Franklin, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; mfrankl2@swarthmore.edu

Catherine H. Crouch, Benjamin D. Geller, Swarthmore College

We report analysis of CLASS responses, self-efficacy survey responses, and course performance for first-year engineering students in introductory physics. Students completed surveys both at the beginning and end of each semester. We examine the relationship between these responses, performance, and student demographics, to determine whether differences are observed between different demographic groups in initial self-efficacy or attitudes, and whether different groups undergo different changes during instruction. We compare our results to previous findings from analyzing equivalent data for life science students.

Session FA: Panel – Race and Gender Performance Gaps: Problems and Alternatives

Location: Marriott - Covington Ballroom I
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Teacher Preparation
Date: Wednesday, July 26
Time: 8:30–10 a.m.

Presider: Dimitri Dounas-Frazer

Institutional over-reliance on race and gender performance gaps may have negative consequences for students from marginalized groups in physics education and STEM education more broadly. Treating race and gender as independent variables often oversimplifies the complexities of students' identities and may perpetuate the problematic idea that the best way to understand race and gender is through comparison of students from different groups. Moreover, the widespread focus on "closing the gap" often uses the average performance of white and/or male students as a standard of excellence for students from marginalized groups. In this panel, we discuss these and other critiques in more detail, and we highlight alternative approaches to attending to race and gender in quantitative and qualitative studies. (**9:30–10 a.m.** *Discussion time*)

FA01: 8:30-8:50 a.m. As Exceptional as Any Monstrosity: Gaps Analyses Past and Present

Panel – Adrienne Traxler, 3640 Colonel Glenn Hwy., Dayton, OH 45435-0001; adrienne.traxler@wright.edu

Documenting educational performance gaps between groups has a long history. From a 21st century perspective, it is not obvious that this tradition traces its roots to the fundamentally racist and sexist work of Western European and North American scientists to prove the intellectual and moral superiority of white men. This history still carries profound consequences for how we conceptualize performance gaps, the emphasis placed on finding them, and the actions (or inactions) that result from their documentation. However, investigation of gaps has also been instrumental in uncovering systemic race and gender discrimination. Understanding gaps drove the discovery of stereotype threat, a theory that encompasses multiple identity facets and interventions. I argue that the gap-gazing paradigm, because of its historical foundation in maintaining a set hierarchy of race, gender, and class, demands a higher level of clarity and responsibility from researchers today. I will conclude with suggestions for navigating these pitfalls.

FA02: 8:50-9:10 a.m. Finding Quantitative Groups with Data-Driven Properties (and Differences)

Panel – Jacqueline Doyle, 11200 SW 8th Street, CP 204, Miami, FL 33199; jacqueline.doyle@fiu.edu

Traditional quantitative analysis involving different demographic groups involves using those demographics as either independent variables in a regression, or group memberships for the purposes of (for example) a t-test. While useful as a first pass, this treatment inherently biases the analysis towards a certain way of thinking, namely, how different is this group from the majority (which usually is some combination of the straight, white, and/or male students), resulting in two primary issues. First, intersectional considerations of student identities are abandoned in favor of statistical power. Second, it obscures possible additional explanations that could confound the relationship. I'll talk about some benefits of using different measures when grouping students, and why it might be preferable for certain research questions to do so.

FA03: 9:10-9:30 a.m. "She Probably Won't Amount to Anything": Counterstorytelling and Physics Education

Panel – Katemari Rosa, Federal University of Bahia, Av. Cardeal da Silva, 213, apt 37 - Federacao, Salvador, BA 40231-305 Brazil; katemari@gmail.com

The underrepresentation of women and people of color in STEM has been well documented in the literature. These studies tend to focus on performance gaps using quantitative analysis. In this presentation, we bring an alternative approach to attending to race and gender through a qualitative study. Grounded in black feminism perspectives and Critical Race Theory, we present a counterstory, that is, a non-dominant narrative, of Christa, a black woman physicist. Her educational and professional trajectories are confronted with the dominant discourse found in the literature around performance and experiences of physics. The findings show the use of counterstorytelling helps to unveil how racism operates in the process of scientific identity construction. We hope to motivate the physics education community to bring more critical perspectives to their work.

Session FB: Designing Labs with Low-Cost Embedded Computers: Raspberry PI, BeagleBone, and Galileo

Location: CC - Breakout 4
Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Educational Technologies
Date: Wednesday, July 26
Time: 8:30–10:20 a.m.

Presider: Randall Tagg

FB01: 8:30-9 a.m. Low-Cost Embedded Computer: BeagleBone Black in the Lab

Invited – Leonardo A. Saunders, University of Colorado Denver, Physics Dept CB 157, P.O. Box 173364, Denver, CO 80217-3364; LEONARDO.SAUNDERS@ucdenver.edu*

The BeagleBone Black (BBB) platform is a low-cost, single-board embedded computer with impressive support from a community of developers, professional scientists and engineers, and hobbyists. Its tin-box size, affordability, and powerful features make it a formidable option for numerous projects ranging from web-based experiments to real-time data acquisition and control. The exciting range of applications of single board computers has encouraged a growing cohort of students at our campus to integrate such devices into applications both in the lab and in everyday life. As a specific example, the BBB has become the preferred prototyping platform for a complex microscope project. This talk will then 1) provide a summary of the BBB features and capabilities, 2) discuss current BBB projects in the CU Denver and Metropolitan State College of Denver physics programs, and 3) present the use of the BBB in developing a low-cost confocal microscope and low-cost 3D microscope stage.

*Sponsored by Randall Tagg

FB02: 9-9:30 a.m. A Low-Cost Approach to Computerizing Hands-on Physics*

Invited – Clayton B. Coutu, University of Alberta, 116 St & 85 Ave., Edmonton, AB T6G 2R3 Canada; ccoutu@ualberta.ca

Andrzej Czarnecki, David Fortin, Lindsay LeBlanc, Mark Freeman, Department of Physics, University of Alberta

Nothing grabs the interest of students like hands-on demonstrations that bring equations and problems off the paper. My goal is to show that by using small single-board computers, it is easy to assemble engaging experiments that do not empty your funds in the process. At the

University of Alberta, we have been using Raspberry Pi's™ to up-keep our undergraduate physics labs; from tasks as simple as connecting to a camera and/or various sensors, to things more demanding like running an entire experiment using Python script. These computers provide an easy-to-use interface that helps students acquire valuable transferable skills that are also essential to any career in physics. Our recent focus has been on applications of the Raspberry Pi™, but there are many related products available that can get you and your class up and running.

*We are grateful for generous support from the University of Alberta through the Teaching and Learning Enhancement Fund, the Department of Physics, and the Faculty of Science.

FB03: 9:30-9:40 a.m. Measuring Alpha Particles with a PiCamera

Contributed – Ian Bearden, Niels Bohr Institute, Blegdamsvej 17, Copenhagen, 2100 Denmark; bearden@nbi.dk

Using a PiCamera and RaspberryPi it is possible to build an alpha particle detector and rudimentary data acquisition system in somewhat less than an hour. This system allows one to "see" alpha particles in real time as well as to do simple qualitative experiments. More quantitative counting experiments can also be performed, but require basic programming skills. Such experiments will be discussed together with possibilities of employing such systems at the secondary school level.

FB04: 9:40-9:50 a.m. Using an Arduino to Monitor a Radiation and CO_2 Sensors

Contributed – Timothy A. Duman, University of Indianapolis, 1400 E Hanna Ave., Indianapolis, IN 46227-3697; tduman@uindy.edu

This talk will present the use of an Arduino to read and record data from a micro Roentgen radiation monitor (Aware Electronics) and K-30 CO_2 sensor (CO2METER.COM). The radiation monitor can be used in radioactive decay experiments and launched on our high-altitude balloon (HAB) platform. The CO_2 sensor has been used to measure the atmospheric concentration on HAB launch. The data from this device can be recorded by a computer or SparkFun's OpenLog module.

FB05: 9:50-10 a.m. Arduino-based Data Acquisition into Excel, LabVIEW and MATLAB

Contributed – Daniel H. Nichols, DeVry University, 3320 N Kilbourn Ave., Chicago, IL 60641; dnichols2@devry.edu

Data acquisition equipment for physics can be quite expensive. As an alternative, data can be acquired using a low-cost Arduino microcontroller. The Arduino has been used in physics labs where the data is acquired using the Arduino software. The Arduino software however, does not contain a suite of tools for data fitting and analysis. The data is typically gathered first, and then imported manually into an analysis program. There is a way however, that allows data gathered by the Arduino to be imported in real time into a data analysis package. Illustrated in this article are add-ins for Excel, MATLAB, and LabVIEW that import data directly from the Arduino and allow for real-time plotting and analysis.

FB06: 10-10:10 a.m. Studying the Relation Between the Pressure and Temperature Using the Dot-39 Cylinder and a Wireless Temperature Sensor

Contributed – Mohammad S. Alshahrani, Bisha College of Tech - TVTC, 2228 Riyadh Main St., Bisha, AS 61922 Saudi Arabia; msscti@gmail.com

The relation between the volume, pressure, and temperature is one of the most important concepts in thermodynamics. The following activity is an attempt to introduce the student to the idea of learning by doing. In fact, they do what was taken in class on the white board in a practical way. Simply, it is by using the Dot 39 cylinder, a wireless temperature sensor, a tablet, refrigerator compressor, and other cheap stuff such as tubes and tapes. Through doing this activity the student will be able to answer the following question. What happens to the inner tank's temperature when its air is removed. This activity expands the students' horizon by making them think, imagine, discuss, and even ask: what if? This also helps to achieve one of the NGSS standards.

FB07: 10:10-10:20 a.m. Redesign of Third-Year Physics and Engineering Physics Laboratory Courses

Contributed – Bei Cai, Queen's University, 64 Bader Lane, Department of Physics, Kingston, ON K7L 3N6 Canada; beicai@queensu.ca*

Robert Knobel, Queen's University

The department of Physics at Queen's University offers both physics and engineering physics programs, and the yearly term-long laboratory courses are an important part of the curriculum. As part of a multi-institution network called TRESTLE, we have recently started to revisit all our laboratory courses using a backward design strategy. Existing laboratory learning outcomes are tabulated. They are compared to the recommendations from the American Association of Physics Teachers for undergraduate physics laboratory curriculum, and evaluated by a faculty panel. A subset of learning outcomes missing from our current program have been identified. We are in the process of mapping the learning outcomes to our lab courses, in hope to scaffold and foster student learning throughout their undergraduate studies. Our third-year lab courses serve an important role in helping students to master the desired learning outcomes before graduation. Rather than having students follow detailed instructions and carry out a list of set experiments, we plan to implement activities where students design the experiment, exploiting the flexibility of modern low-cost technology. We have implemented a new pendulum experiment using Arduino microcontrollers and are considering possibilities of using Raspberry Pi for data acquisition to replace the old multi-channel analyzers in our nuclear experiments. We plan to develop some hands-on, supportive activities throughout the course to familiarize students with these processing and control units, and to better help them in their design projects. In this talk we will report our progress of these lab redevelopment efforts.

*Sponsored by James Fraser, Queen's University

Session FC: History and Philosophy in Physics Courses

Location: CC - Breakout 5
Sponsor: Committee on History and Philosophy in Physics
Date: Wednesday, July 26
Time: 8:30–10:30 a.m.

Presider: Harvey S. Leff

FC01: 8:30-9 a.m. Albert Michelson and the Dichotomy between Megaprojects and Table-top Science

Invited – Philip Taylor, Case Western Reserve University, 10900 Euclid Ave., Cleveland, OH 44106-7079; plt@case.edu

During the past 130 years the range of sizes and costs for scientific apparatus has expanded enormously. While some groundbreaking science is still done at modest cost, other experiments now require several billions of dollars to achieve their goals. A description of some significant milestones in the career of Albert Abraham Michelson illustrates how in this one individual's life this divergence may have had its first exemplar, as his vision expanded beyond the exquisitely precise interferometer used in the Michelson-Morley experiment to the mile-long vacuum tube used in his later measurements of the speed of light.

FC02: 9-9:30 a.m. Adventures with Lissajous Figures

Invited – Thomas B. Greenslade, Jr., Kenyon College, Department of Physics, Gambier, OH 43022; greenslade@kenyon.edu

When you see a circle, you probably think of a plane figure that is everywhere distant from a point. I see a Lissajous figure, formed by two simple harmonic motions of the same frequency and amplitude, added together at right angles with a 90° phase difference. As in the case of Wheatstone, who did not invent his eponymous bridge, Lissajous did not invent the figures. We ought to call them Bowditch Figures after the late 18th century polymath who first described them in 1815 in The American Journal of Science. I will show examples of Harmonographs, the mechanical devices that are used to draw the figures.

FC03: 9:30-10 a.m. Entropy as Disorder: History of a Philosophical Misconception

Invited – Daniel Styer, Oberlin College, Oberlin, OH 44074; dan.styer@oberlin.edu

The concept of entropy originated as a quantifiable entity for finding the peak efficiency of a heat engine, and has morphed into a catch-all title for anything bad. The story of this transformation is as intricate as any Brayton cycle. Henry Adams (grandson of John Quincy Adams) plays a prominent role.

Session FD: Panel – Multiple Career Paths in PER

Location: Marriott - Covington Ballroom II
Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Space Science and Astronomy
Date: Wednesday, July 26
Time: 8:30–10:30 a.m.

Presider: Lindsay Owens

Panelists:

Sam McKagan, Seattle, WA

Ramon Barthelemy, APS

Brad Conrad, Society of Physics Students

P. Rai Menges, Cincinnati, OH

Session FE: Panel – Making Change Through Science Policy

Location: Marriott - Covington Ballroom III
Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on Research in Physics Education
Date: Wednesday, July 26
Time: 8:30–10:30 a.m.

Presider: Adrienne Traxler

Advocating for education and science literacy in our classrooms and institutions is important, but the broader national landscape is shaped by policy. Speakers at this panel will discuss both the general framework of science policy and issues specific to physics. Bring your questions and your ideas—the 2018 summer AAPT meeting is coming to Washington, DC, and would be a great opportunity for lobbying.

FE01: 8:30-10:30 a.m. Science. Power. Policy

Invited – Bethany Johns, American Institute of Physics, One Physics Ellipse, College Park, MD 20740, bjohns@aip.org

Balancing the federal budget, lack of compromise, and making America great ? these ideologies are guiding the debate in Washington, DC and influenced the 2016 election campaigns. This rhetoric affects you, your career, and funding for the sciences. The current White House has begun to implement policies that are counter to how the science community believes innovation will lead to better the economy, including increasing funding for the sciences and education. Meanwhile, Congress debates about how the federal spending deficit impacts our global economic competitiveness and how budget cuts are necessary for a stable government. The current political climate has caused Congress?s approval rating to reach an all-time low and created confusion on how the federal budget process usually works. There are points throughout the year when you can make an impact on the policy making process. I will speak on the current events on Capitol Hill, the current climate for science funding, what the AIP Government Relations is doing for you, and the impact you can make on the policy making process.

Session FF: Multi-Messenger Astronomy in the Age of GR and Gravitational Waves

Location: CC - Breakout 6
Sponsor: Committee on Space Science and Astronomy
Date: Wednesday, July 26
Time: 8:30–10:30 a.m.

Presider: Edward Prather

FF01: 8:30-9 a.m. Gravitational Waves, LIGO, and Gravitational-Wave Astronomy

Invited – Amber L. Stuver, LIGO Livingston Observatory, 1003 E Tom Stokes Ct., Baton Rouge, LA 70810; stuver@ligo-la.caltech.edu

About 1.3 billion years ago, two black holes merged into one releasing more energy than all of the stars in the universe for a brief instant. On Sept. 14, 2015, the gravitational waves from these black holes reached Earth and resulted in the first direct observations of gravitational waves. By observing the universe with this new medium, the new field of gravitational-wave astronomy began. In this talk, we will present an overview of what gravitational waves are, how LIGO detected them, and what we've learned so far. We will also discuss the educational tools that are prepared for the development of educators as well as materials and activities that can be used in the classroom.

FF02: 9-9:30 a.m. Examining the Observational Toolbox of Future Astronomers

Invited – Shane L. Larson, Northwestern University/Adler Planetarium, 2145 Sheridan Road, Evanston, IL 60208; s.larson@northwestern.edu

A vast amount of what we have learned about the Cosmos has been gleaned from telescopes. The advent of gravitational wave astronomy, from LIGO to LISA to Pulsar Timing Arrays, is expanding the suite of tools available to us for probing astrophysical phenomena. Astronomers today, and the students in our classrooms, will only know a Universe that is simultaneously defined by data from the electromagnetic and gravitational wave spectrums. In this talk we'll take a broad view of the Universe, in observation technique, source class, and wavelength regime (both photon and gravitational wave). Our goal is to examine the opportunities and challenges with integrating these traditional and new ways of detecting the Universe into our science and classrooms.

FF03: 9:30-10 a.m. PER on Gravitational Waves with Astronomy 101

Invited – Gabriela Serna, Syracuse University, 242 Fellows Ave., Syracuse, NY 13210; geserna@syr.edu

Joshua Smith, Michael Loverude, California State University, Fullerton

John Tillotson, Syracuse University

Edward Prather, University of Arizona

Recent LIGO discoveries in the field of gravitational-wave astronomy have opened up a new window into the universe. A multi-institutional team of physics and astronomy education researchers and gravitational-wave scientists are developing new active learning and assessment materials designed to help college-level introductory astronomy students make sense of these recent discoveries. In this talk, I will highlight key findings from our recent work to develop, and test the effectiveness of a suite of new active learning activities designed to increase students' awareness of, appreciation for, and fundamental understanding of gravitational-wave astronomy.

FF04: 10-10:30 a.m. Unpacking General Relativity – Choosing Representations for Teaching Novice Learners

Invited – Timothy Chambers, University of Michigan, HH Dow Building, 2300 Hayward St., Ann Arbor, MI 48109; timchamb@umich.edu*

Colin S. Wallace, University of North Carolina - Chapel Hill

Edward E. Prather, University of Arizona

Teaching introductory astronomy is uniquely challenging; many students find the material interesting but lack the quantitative skills commonly associated with scientific thinking. Instructors must therefore find ways to engage these students in sophisticated and meaningful scientific reasoning that do not rely on mathematical formalism. One important way is thoughtful selection and construction of the representations used to both teach and assess astronomy content knowledge. In this talk we share our experiences teaching general relativity to Astro 101 students via modern, exciting topics such as exoplanet detection by gravitational microlensing. We have chosen and created pedagogical discipline representations of physical phenomena that our students can unpack and manipulate to engage in sophisticated, robust thinking about cutting-edge gravitational phenomena. We hope to encourage and support other instructors in considering how the theory of representations may be applied to their own teaching and curriculum.

*Sponsored by Edward Prather

Session FG: PIRA Session – 3D Printing in Labs and Demonstrations

Location: CC - Ballroom D
Sponsor: Committee on Apparatus
Date: Wednesday, July 26
Time: 8:30–10:15 a.m.

Presider: *David Haley*

FG01: 8:30-9 a.m. 3D Printing Physics Lab and Demonstration Equipment

Invited – Paul Fratiello, Eckerd College, 4200 54th Ave. S., St. Petersburg, FL 33711-4744; fratiepj@eckerd.edu

Physics lab and demonstration equipment can be quite expensive for the limited resources of the average high school physics teacher. 3D printers have started showing up in media centers, technology, and robotics clubs. How can you, as a physics teacher, take advantage of existing resources you may already have in your school? This presentation addresses the use of 3D printers to supplement you existing demonstration or lab equipment. It will include the basics and costs of 3D printers and printing, free 3D modeling software, and online sources of free 3D printable material. Finally, a variety of 3D printed apparatus will be showcased.

FG02: 9-9:30 a.m. 3D Printing Allows for the Investigation of Real World Problems

Invited – Steve Dickie, Divine Child High School, 1001 N. Silvery Lane, Dearborn, MI 48128-1544; dickie@divinechildhighschool.org

Physics is one area that should be immune to the sentiment of, "When am I going to use this?" Yet I've heard this voiced in my class and to be fair I doubt many of my former students have ever needed to determine the flight time of a projectile launched in a vacuum or the speed of a hoop rolling down a ramp in their careers. 3D printing gives you the opportunity to either create or help your students create equipment to address engaging problems that go beyond the textbook. These problems might be the subject of national news or maybe just viral videos. In this presentation, I will share projects done by and with my students that benefited from the inclusion of 3D printing.

FG03: 9:30-10 a.m. Controlling an Induction Coil with LabVIEW DAQ*

Invited – Urs Lauterburg, University of Bern, Physikalisches Institut, Sidlerstrasse 5, Bern, BE 3012 Switzerland; urs.lauterburg@space.unibe.ch

An IGBT (Insulated Gate Bipolar Transistor) powered induction coil is used to create discharge arcs in air. The process is controlled by a LabVIEW program and a NI-USB multifunction DAQ device. The physical behavior is shown and illustrated by the numeric and graphical displays of the measurements. The highly dynamical system is a motivating educational example for university students that enroll in domains of science and engineering. Some parts of the rather simple experimental setup may be produced by a 3D printer.

*David Haley also member of PIRA, the Physics Instructional Resource Association/ The Physics Institute of the University of Bern, Switzerland

FG04: 10-10:15 a.m. Continued Development of 3D Printed Physics Tactile Learning Objects for Accessibility

Contributed – Steven C. Sahyun, University of Wisconsin - Whitewater, 800 W. Main St., Physics Dept. Whitewater, WI 53190-1319; sahyuns@uww.edu

Christopher Marshall, UW-Whitewater

This talk describes continued development of objects that have been created specifically to aid students who would benefit from tactile objects (manipulatives) to improve their understanding of physics. These objects may be downloaded by teachers needing tactile objects for their students and produced on their local 3D printer. Some of these recently developed objects include: coordinate axes, elemental spectra, magnetic field (right-hand rule), Bravais lattice unit-cells and optics thin-lens ray diagrams. While the objects may be of use to any student needing a physical object to gain understanding, many of the objects are also labeled in braille to aid students who have little or no vision.

http://sahyun.net/3dprint

Session FH: PER: Examining Content Understanding and Reasoning – III

Location: CC - Breakout 7
Sponsor: AAPT/PER
Date: Wednesday, July 26
Time: 8:30–9:20 a.m.

Presider: *Paul Walter*

FH01: 8:30-8:40 a.m. Identifying High Leverage Practices in Learning Assistant Implementations

Contributed – Daniel Caravez, CSU Chico, 48 Tara Terrace Apt. 1, Chico, CA 95973; dcaravez2@gmail.com

Jayson Nissen, Nancy Caravez, Angelica De La Torre, Ben Van Dusen, CSU Chico

The Learning Assistant (LA) model is designed to provide a platform to support a wide variety of classroom specific transformations. This investigation examines the impacts of LAs across implementations to identify discipline-specific high-leverage LA practices. To do this, we will leverage the statistical power of the Learning About Student Supported Outcomes (LASSO) platform to create Hierarchical Linear Models that include student concept inventory data, student demographics, and course level data from science classes across the country. Implications for the implementation of LA programs will be discussed.

FH02: 8:40-8:50 a.m. Item Response Theory on the Force and Motion Conceptual Evaluation

Contributed – Rachel Henderson, West Virginia University, 135 Willey St., Morgantown, WV 26506; rjhenderson@mix.wvu.edu

John Stewart, West Virginia University

Adrienne Traxler, Wright State University

Rebecca Lindell, Purdue University

Gender gaps on the various physics concept inventories have been extensively studied. It has been shown that on average, men score 12% higher than women on mechanics concept inventories and 8.5% higher than women on electricity and magnetism concept inventories. Item response theory (IRT) and Differential Item Functioning (DIF) analysis have been used to examine the Force Concept Inventory and have identified multiple items that are unfair to women. In the current study, IRT and DIF will be used to explore gender biases in the Force and Motion Conceptual Evaluation. The IRT difficulty and the discrimination of the 43 items will be examined. DIF analysis will employ the Mantel-Haenszel statistic to identify any gender biases.

FH03: 8:50-9 a.m. New Measures of Equity – Synergies from the IMPRESS Program

Contributed – Eleanor C. Sayre, Kansas State University, 329 Cardwell Hall, Manhattan, KS , KS 66506; esayre@phys.ksu.edu

Florian Genz, University of Cologne / GERMANY

Benjamin Archibeque, Kansas State University

Mary Bridget Kustusch, DePaul University

Scott Franklin, RIT

Equity and Inclusion became key concepts in modern education. Still they are neither well defined nor measurable…yet. This presentation will give an insight of the current progressions of the IMPRESS research squad tackling this key problem. Why do we measure Equity? Especially, in physics education women and ethnic minorities are underrepresented and even catching up slower than in other fields. Secondly, underrepresentation perpetuates stereotypes and minority students are at risk of internalizing these external expectations. Moreover, due to self-fulfilling prophecy, women are still given fewer job offers in leading positions than men in almost all fields. This presentation will focus on the measurement of equity during small group work in the context of science and metacognitive learning.

FH04: 9-9:10 a.m. Writing Time Capsules for Student Self-Assessment

Contributed – Gail S. Welsh, Salisbury University, 1101 Camden Ave., Salisbury, MD 21801; gswelsh@salisbury.edu

My students create end-of-semester portfolios providing evidence of and reflecting on what they have learned in the course. In order to make the students' reflections more meaningful and to give them a baseline from which to measure growth in understanding, I use a series of writing assignments I refer to as Time Capsules. At the beginning of a module students are asked to write about what they know or think about the topics in response to prompting questions. At the end of the module they revisit their Time Capsule and write a reflection on their learning, which forms the basis for the end-of-semester portfolio. Specifically, they are asked to address how their current understanding of the material differs from their original thoughts recorded in the Time Capsule. I will describe my use of these writing assignments in several physics majors' courses at Salisbury University.

FH05: 9:10-9:20 a.m. Identifying the Disciplinary Alignment of Student Ideas Using Textbook Analysis

Contributed – Mashood KK, Michigan State University, Physics Education Research Lab, East Lansing, MI 48824-2320; mashoodkk123@gmail.com

Vashti Sawtelle, Charles Anderson, Emily Scott, Michigan State University

Sonia Underwood, Florida International University

Rebecca Matz

The emphasis on interdisciplinary thinking, both at the policy level and academia, has resulted in the development of new undergraduate science courses and curricula, but assessing interdisciplinary thinking remains challenging. An important consideration in this regard is to understand the extent to which students invoke different disciplines in their explanations about scientific phenomena. Literature review reveals that this process is often done by seeking opinion from content experts. We propose using student reflections and textbook analysis as two other possible modes for doing this. This poster discusses the process of textbook analysis, illustrating its advantages and limitations. Our data constitute student explanations of a set of everyday interdisciplinary phenomena such as the solidification of egg white on boiling. These phenomena were chosen such that they involve ideas from physics, chemistry and biology. Students were asked to explain them on the basis of what they have learned in different science courses.

Session FI: Teacher Training/ Enhancement

Location: CC - Breakout 8
Sponsor: AAPT
Date: Wednesday, July 26
Time: 8:30–9:50 a.m.

Presider: Beverly Taylor

FI01: 8:30-8:40 a.m. A Conceptual Framework for Integrated K-12 STEM Education

Contributed – Lynn A. Bryan, Purdue University Beering Hall Rm. 4132, West Lafayette, IN 47907-2036; labryan@purdue.edu

Drew Ayers, Selcen Guzey, Purdue University

One of the central goals of the Center for Advancing the Teaching and Learning of STEM (CATALYST) at Purdue University is to positively impact the integration of STEM teaching and learning in K-12 classrooms. The Next Generation Science Standards (NGSS Lead States, 2013) and science standards of many states emphasize incorporation of engineering practices in science instruction. Drawing on the work of scholars who have inspired the meaningful integration of STEM disciplines at the K-12 level (e.g., Sanders, 2009; Sanders & Wells, 2010), we define integrated STEM as teaching and learning of content and practices of science and/or mathematics through integration of practices of engineering and engineering design of relevant technologies. Here we describe the learning goals for integrating engineering practices in K-12 physics instruction. We will share exemplars of recent CATALYST efforts in this area. Finally, we will articulate a guiding conceptual framework for designing integrated STEM curricula.

FI02: 8:40-8:50 a.m. "Dude, Where's My Helmet?": Integrating Engineering Design into Middle School Physics

Contributed – Carina M. Rebello, Purdue University, Physics Bldg. Rm. 245, 525 Northwestern Ave., West Lafayette, IN 47907-2040; rebelloc@purdue.edu

Lynn A. Bryan, Purdue University

One of the central goals of the Center for Advancing the Teaching and Learning of STEM (CATALYST) at Purdue University is to positively impact the integration of STEM teaching and learning in K-12 classrooms. The Next Generation Science Standards (NGSS Lead States, 2013) and science standards of many states emphasize incorporation of engineering practices in science instruction. To this end, CATALYST has developed a guiding conceptual framework for designing integrated STEM curricula. In this talk we describe how we applied our framework to design a lesson for middle school students that integrates concepts in biology and physics (i.e. momentum and impulse) with engineering practices to design a safety helmet. We will share our experiences from a summer workshop where we used these materials with middle school teachers. Finally, we will discuss implications of designing middle school curricula for physics that integrates the learning of physics with other STEM disciplines.

FI03: 8:50-9 a.m. Hydroponics: A Context for Integrated STEM in High School Physics

Contributed – N. Sanjay Rebello, Purdue University, Physics Bldg. Rm. 228, 525 Northwestern Ave., West Lafayette, IN 47907-2040; rebellos@purdue.edu

Hui-Hui Wang, Minjung Ryu, Lynn A. Bryan, Purdue University

One of the central goals of the Center for Advancing the Teaching and Learning of STEM (CATALYST) at Purdue University is to positively impact the integration of STEM teaching and learning in K-12 classrooms. The Next Generation Science Standards (NGSS Lead States, 2013) and science standards of many states emphasize incorporation of engineering practices in science instruction. To this end, CATALYST has developed a guiding conceptual framework for designing integrated STEM curricula. In this talk, we describe how we applied our framework to design a lesson for high school students that integrates the learning of physics (electric circuits), chemistry and agriculture concepts in a context of designing a hydroponics system. We will share our experiences from a summer workshop with high school teachers. Finally, we will discuss the implications for high school physics curricula that integrates learning of physics with other STEM disciplines.

FI04: 9-9:10 a.m. Next Gen PET and the Faculty Online Learning Community[1]

Contributed – Fred M. Goldberg, San Diego State University, 6475 Alvarado Road, Suite 206, San Diego, CA 92120; fgoldberg@sdsu.edu

Sean Smith, Horizon Research, Inc.

Next Generation Physical Science and Everyday Thinking (Next Gen PET)[2] is a research-based, guided inquiry curriculum for preservice and inservice elementary teachers, designed to provide students with learning experiences aligned with the Next Generation Science Standards. The pedagogical design provides many opportunities for small group and whole class discussions and for instructors to monitor and study student thinking. Versions of Next Gen PET are available for either small or large enrollments, and covering either physics or physical science content. Recently, we have established a Faculty Online Learning Community,[3] consisting of faculty interested in improving their instruction, studying student thinking and conducting classroom-based research using the Next Gen PET curriculum. Faculty in this community have participated in evaluation of student content learning. This talk will provide a brief overview of the curriculum, the online community, and initial student learning impact data.

(1) Supported by grants from the National Science Foundation and the Chevron Foundation (2) http://nextgenpet.iat.com (3) http://www.ngpfolc.org

FI05: 9:10-9:20 a.m. Incorporating Engineering Design Activities into a Curriculum for Pre-service Elementary Education Majors

Contributed – Paula V. Engelhardt, Tennessee Technological University, 110 University Drive, Box 5051, Cookeville, TN 38505-0001; engelhar@tntech.edu

The Next Generation Science Standards emphasize disciplinary core ideas, scientific and engineering practices, and crosscutting concepts. Next Generation Physical Science and Everyday Thinking (Next Gen PET)[1] incorporates all three into the design of the curriculum. This talk will focus on incorporating engineering design activities into a one-semester studio-style, guided inquiry physics course for pre-service elementary education majors. At the end of each unit, students complete an engineering design task related to the concepts they have been studying. NGSS breaks engineering design into three stages: 1) defining and delimiting an engineering problem, 2) developing possible solutions and 3) optimizing the design solution. Working in small groups, students are guided through these three stages culminating, in most cases, with the construction of a working model of their design. Brief descriptions of each engineering design activity and examples of student work will be presented.

1. http://nextgenpet.iat.com

FI06: 9:20-9:30 a.m. Developing Pre-service Elementary Teachers' Pedagogical Content Knowledge in Next Gen PET

Contributed – Stephen Robinson, Tennessee Technological University, Dept. of Physics, Box 5051, Cookeville, TN 38505; sjrobinson@tntech.edu

Danielle Boyd Harlow University of California, Santa Barbara

Science content courses for future elementary teachers can help them develop the pedagogical content knowledge needed to make appropriate instructional decisions in their own classrooms. The Next Generation Physical Science and Everyday Thinking (Next Gen PET) materials[1] begin to address this development by including activities that engage students in issues of teaching and learning in the context of the science and engineering practices identified in the Next Generation Science Standards. In these activities pre-service teachers watch videos of children engaged in activities, interview children in person about their science ideas, and facilitate explorations by small groups of children. They then collaborate in small groups to analyze the children's thinking, reflect on their experiences, and discuss implications for their own future teaching. We describe how these activities can be integrated into a Next Gen PET course and give examples of student work.

1. http://nextgenpet.iat.com

FI07: 9:30-9:40 a.m. Preparing Physicists to be Informal Educators

Contributed – Michael Bennett, JILA Physics Frontier Center and University of Colorado Boulder, 440 UCB, Boulder, CO 80303; michael.bennett@colorado.edu*

Kathleen A Hinko Michigan State University

Brett Fiedler, Noah D Finkelstein University of Colorado Boulder

PISEC, the Partnerships for Informal Science Education in the Community, is an informal after-school physics education program that partners university mentors ("University Educators," or UEs) with local K-8 students to engage in hands-on, open-ended physics activities. To achieve the goals of advancing UE and K-8 students alike, UEs undergo preparation each semester where they practice curricular activities, reflect on school site demographics and culture, and develop skills in communicating scientific knowledge at an appropriate public level. PISEC's partnership with the CU Boulder physics education research group allows us to engage in research on PISEC and incorporate feedback to iteratively develop the program. Recent results have shown that UEs tend to engage in one of three different "pedagogical modes," (Hinko, PR:PER 2016), avenues of communication with students. We have incorporated these findings into our UE preparation and will discuss the implementation and preliminary outcomes on its effect on UE training.

*Sponsored by Noah D. Finkelstein

FI08: 9:40-9:50 a.m. The Effectiveness of Assembly Style Science Demonstrations on Student Learning

Contributed – Patrick R. Morgan, Michigan State University, 755 Science Rd., East Lansing, MI 48824; morgan@pa.msu.edu

Science demonstrations and experiments are an important part of any science lesson. They help students learn and recognize the principles and concepts, and can be a great amount of fun as well. In particular, the "fun" aspect can play an important role. Science assemblies have become regular occurrences around the country, with large demonstrations to excite students about learning the sciences. However, are students learning from these types of presentations? If so, what are they learning during these presentations? Do students recognize the demonstrations from previous years, and if so do they recall what will happen? This study followed MSU Science Theatre, a nonprofit undergraduate outreach group, on their annual Upper Peninsula trip. By looking at the audience responses during and after the performance, as well as the unique presentation style of Science Theatre, this study will show the benefits and challenges of these types of assemblies.

Session FJ: Physics Education Research

Location: CC - Ballroom C
Sponsor: AAPT
Date: Wednesday, July 26
Time: 8:30–9:30 a.m.

Presider: TBA

FJ01: 8:30-8:40 a.m. Enactment of CKT-Energy While Designing Assignments and Assessments for Instruction

Contributed – Robert C. Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901; robert.zisk@gse.rutgers.edu

Eugenia Etkina

Drew H. Gitomer

Content knowledge for teaching (CKT) is the knowledge that teachers have that enables them to effectively teach a particular subject (Ball, Thames, and Phelps, 2008). As such, when examining instruction, we should be able to find evidence of the enactment of a teacher's CKT. Typically, instruction is measured through observations of practice, but the assignments and assessments that teachers design and use during instruction can also offer insight into the expectations and instructional practice of the classroom. In this talk, we will draw on data collected from a study that set out to examine the relationship of a teacher's CKT for teaching energy, their instructional practice, and student outcomes. We will use these data to describe how the enactment of CKT is measured through the assignments and assessments that teachers developed for their energy unit, and how teachers' varying levels of CKT relate to the instructional tasks of the classroom.

FJ02: 8:40-8:50 a.m. Engaged and Individual Learning Using a Student's Own Mistakes

Contributed – Zengqiang Liu, Saint Cloud State University, 720 4TH AVE S WSB-308, Saint Cloud, MN 56301; zliu@stcloudstate.edu

Although instructors meticulously grade and comment student papers, expecting students to learn from their mistakes, students often dismiss their papers instead of learning from them. Thus an instructor spends valuable time unilaterally assessing students but often have to accept less-than desirable DFW rates. In order to engage students in learning and individualize their experiences for better retention and student success, I have devised and implemented a new grading process that makes students recognize their papers as learning resources and motivate them to learn from their own mistakes. The grading process motivates students to identify and correct their mistakes, then explain their mistakes and corrections to their instructor, with the promise of grade improvements. Through this process, I have actively engaged the majority of my students in self-motivated and individual learning. I will present preliminary data on student attitude and content knowledge improvement as a result of this new grading process.

FJ03: 8:50-9 a.m. Essential Skills Training: Fluency Improvement, Implementation Recommendations, and Student Reception

Contributed – Brendon D. Mikula, Indiana State University, 600 Chestnut St, Room 035, Terre Haute, IN 47809-1902; brendon.mikula@indstate.edu

Andrew F. Heckler, Ohio State University

The Essential Skills Framework is a general framework by which instructors can help students improve their accuracy and fluency with basic procedural skills required in typical physics problems, such as vector components or vector addition, without requiring additional time spent in lecture. The framework makes use of deliberate practice, mastery grading, immediate answer-based feedback, and other well-researched principles from cognitive psychology, all delivered via online weekly assignments. We conducted a study with over 1,500 students in actual course settings and found large gains in essential skills accuracy (> 1 standard deviation from two to three hours of total training time). This talk will focus on important details of these results including improvement in fluency (decreased time required to complete the task), relationships between course performance and Essential Skills performance, the effects of awarding credit for the Essential Skills as extra credit versus course credit, and student reception to the training.

FJ04: 9-9:10 a.m. Predictive Measures of Student Performance in Introductory Calculus-based Physics

Contributed – Michael A. Greene, University of Texas at Arlington, 213 Hollandale Circle, Arlington, TX 76010; michaelagreene@mavs.uta.edu

Ramon E. Lopez, University of Texas at Arlington

Various factors are known to correlate with performance in physics and other STEM courses. In this study, we report on students' performance in an introductory calculus-based physics course at the university level and correlate their performance (as measured by final grade) with a variety of measures of academic and cognitive ability. These measures include mathematical and English language ability (as measured by the SAT), incoming GPA, and spatial and scientific reasoning ability (as measured by the Mental Rotation Test and Classroom Test of Scientific Reasoning). We also consider the effect on student performance of factors such as employment status, and science and mathematics self-efficacy (as measured by a survey). We find that the strongest predictor of student success is mathematical ability. In addition to single-variable linear regression models, we also include several factors in a multivariate linear model, and report the correlation trends over time in successive semesters.

FJ05: 9:10-9:20 a.m. Impact of an iPad-based Physics Curriculum on Physics Teacher Preparation

Contributed – Deepika Menon, Towson University, 8000 York Road, Towson, MD 21252; dmenon@towson.edu

Meera Chandrasekhar, Dorina Kosztin, Douglas Steinhoff, University of Missouri – Columbia

While mobile technologies such as iPads and tablets are increasingly becoming part of elementary teaching, researchers and practitioners are continually finding better ways to train prospective teachers to meaningfully integrate mobile technologies into their future instructional practices. In this study, we engaged preservice elementary teachers in learning physics using the Exploring Physics curriculum available as an iPad application. We investigate the changes in preservice teachers' conceptual learning and technology self-efficacy and the relationship between the two constructs before and after their participation in a college-level physics content course. Data sources include two surveys to measure physics content knowledge and technology self-efficacy at the beginning and end of the semester, and semi-structured interviews with selected participants. Data analyses include both quantitative statistical procedures as well as grounded theory techniques to understand the affordances of the Exploring Physics curriculum to support preservice teachers' conceptual understanding and technology self-efficacy. The preliminary results of this ongoing research will be presented. Findings will have implications for preservice teacher preparation for future use of technology in teaching physics.

FJ06: 9:20-9:30 a.m. Professional Development of In-service Physics Teachers

Contributed – Osnat Eldar, Oranim Academic College of Education Israel, 25 Lotem St. Timrat, 3657600; Israel eldar@oranim.ac.il

This presentation described a case study focusing on the design and study of a metacognitive approach to the professional development of in-service high-school physics teachers, responding to the need to develop effective professional development programs in domains that require genuine changes in teachers' views, knowledge, and practice. This approach emphasizes the important role of metacognition for teaching and learning, helping the teachers to develop the metacognitive lifelong learning skills, and to reconstruct their conceptual knowledge and procedural strategies when necessary. The course is part of a two-year MEd program designed for experienced high school science teachers, who are interested in their personal and professional development and intend to continue to teach at school.

Session FK: PER: Diverse Investigations

Location: CC - Breakout 10
Sponsor: AAPT
Date: Wednesday, July 26
Time: 8:30–10:30 a.m.

Presider: TBA

FK01: 8:30-8:40 a.m. Applying Eye-Tracking Technology to Investigate Cognitive Load Theory*

Contributed – Tianlong Zu, Department of Physics and Astronomy, Purdue University, 2491 Sycamore Ln., West Lafayette, IN 47906; tzu@purdue.edu

John Hutson, Lester C. Loschky, Department of Psychological Sciences, *Kansas State University*

N. Sanjay Rebello, Purdue University

Cognitive load theory (CLT) requires that learning material should not impose cognitive load exceeding a learner's working memory capacity. CLT posits three types of loads: intrinsic, extraneous, and germane. Each has unique implications for learning. Many physiological measures can differentiate different levels of total cognitive load. There has been little research to investigate their sensitivity to the three kinds of load other than subjective ratings, which are often unreliable. In this study we report how some eye-tracking based physiological parameters are related to the three kinds of cognitive load. Our study design is based on clear manipulation of the three kinds of load. In general, participants in our study have low prior knowledge regarding the material used. An operation memory span task was conducted to control the effect of working memory capacity.

*Supported in part by NSF grant 1348857. Opinions expressed are those of the authors and not necessarily those of the Foundation.

FK02: 8:40-8:50 a.m. Blackbox Science: Hidden Science Practices Used in the Optics Workplace

Contributed – Anne E. Leak, Rochester Institute of Technology College of Science, 85 Lomb Memorial Drive, Rochester, NY 14623; aelsps@rit.edu

Zackary Santos, Kelly N. Martin Erik Reiter, Benjamin Zwickl, Rochester Institute of Technology

To prepare physics majors for future careers, it is important for faculty to understand the practices and competencies necessary for success. To explore how these are acquired and used in optics and photonics-related careers, we conducted 28 semi-structured interviews with managers and recent hires at companies in Western New York. Employees described the science they used in their jobs, their strengths and weaknesses, and where their competencies were developed. Managers were interviewed to provide an additional perspective on expected competencies and education provided on the job. Using hierarchical and emergent coding methods, we explored 1) the science new hires engage in, 2) valuable competencies for success, and 3) where essential learning takes place. Our results highlight the variety of ways new hires learn science and what competencies are most valuable on the job. Results have potential implications for revealing and integrating real industry practices into the undergraduate physics curriculum.

FK03: 8:50-9 a.m. Coordinating Multiple Resources to Learn Physics

Contributed – Trevor S. Volkwyn, Uppsala University Lägerhyddsvägen 1 Uppsala, 752 37 Sweden; trevor.volkwyn@physics.uu.se*

John Airey, Stockholm University and Uppsala University

Bor Gregorcic, Filip Heijkenskjöld, Cedric Linder, Uppsala University

It has been argued that for any given physics task there is a critical constellation of resources that students need to become proficient in handling in order for physics learning to take place. This is because different resources offer access to different information i.e. they have different pedagogical and disciplinary affordances. A laboratory exercise requiring coordination of multiple resources was designed to help students appreciate the movability of coordinate systems. Initially students were unable to coordinate the manipulation of a hand-held measuring device (IOLab) and observe changes in three readouts on a computer screen, whilst simultaneously drawing conclusions in their discussions with each other and the facilitator. However, the introduction of a paper arrow allowed students to quickly coordinate the resources and begin to experience the movability of coordinate systems. The study confirms earlier work on critical constellations of resources and the functioning of persistent resources as coordinating hubs.

*Sponsored by Cedric Linder

FK04: 9-9:10 a.m. Impact of Instructor Beliefs Surrounding Reflection on Students

Contributed – MacKenzie Lenz, Oregon State University, 301 Weniger Hall, Corvallis, OR 97331; lenzm@oregonstate.edu

Elizabeth Gire, Oregon State University

After solving a problem, professional physicists spend time asking, "Does this answer make sense? Is my answer reasonable?" A common instructional goal is for students to do the same. Some instructors believe that reflection should be formally required on assignments while others do not. These differing beliefs may affect how students learn and use different reflection strategies and whether students believe that reflecting on answers is important. We will examine the relationship between three different instructors' beliefs about reflection, their students' use of reflection on homework, and the students' beliefs about reflection.

FK05: 9:10-9:20 a.m. Measurable Learning Objectives Project

Contributed – Suzanne White Brahmia, University of Washington, Department of Physics, Seattle, WA 98195-1560; brahmia@uw.edu

The collaborative development of physics learning objectives[1] can provide a framework for sustaining pedagogical and cultural change. MLOP (Measurable Learning Objectives Project) is a new national effort that builds on the products and outcomes of the Science Education Initiatives at UC Boulder and UBC. MLOP focuses on two growth areas. The first is uniformly addressing introductory physics learning objectives; we consolidate the outcomes of prior systematic efforts in the majors' courses creating a robust set of measurable learning objectives for the introductory sequence. The second is linking measurement with these objectives; we seek measures that help determine whether or not specific learning objectives have been met. In this talk I will introduce the structure of MLOP, its role helping to focus the community of faculty engaged in a course transformation, and its potential as a framework for modifying course content and professional development.

1. S. Chasteen et al.(2011)

FK06: 9:20-9:30 a.m. SIMBA and PUMBA: Surveys for Developing and Measuring Student Buy-in

Contributed – Matthew Wilcox, University of Central Florida, 4111 Libra Drive, Physical Sciences Bldg. 430, Orlando, FL 32816; mwilcox1@knights.ucf.edu

Jacquelyn J. Chini, University of Central Florida

Studio physics classes typically implement collaborative student-centered instructional techniques that students may not expect when they first come to class. The differences between student expectations and the reality of the studio class can lead to student resistance to these student-centered instructional techniques. Getting students to adjust their expectations to align with the instructional design may be the start of reducing student resistance. Further reduction in student resistance may come from efforts to get students to agree that the studio class format is the best way to learn physics. We refer to the appropriate expectations of and agreement with the class format as "buy-in". We have developed a survey for instructors and another for students to determine successful methods for generating student buy-in. We report on the development of these surveys and how they will be used to determine the best methods for buy-in achievement.

FK07: 9:30-9:40 a.m. Student Learning of Legendre Transformations with a Mechanical Analogue

Contributed – Michael Vignal, University of Oregon and Portland State University, Department of Physics, 301 Weniger Hall, Corvallis, OR 97331-6507; vignalm@oregonstate.edu

Elizabeth Gire, Oregon State University

While student difficulties with thermodynamics are well documented, researchers and instructors have struggled to develop pedagogical tools and strategies to help students navigate challenging thermodynamic concepts. In response, members of the Department of Physics at Oregon State University developed the partial derivative machine (PDM) as a mechanical analogue to a thermodynamic system. In this talk, we discuss two sets of teaching interviews with junior-level physics majors, in which students learned about Legendre transformations on the mechanical PDM and then attempted a thermodynamics transfer problem. Our analysis of these interviews considers student affect and performance on the transfer problem to assess the effectiveness of the PDM as a teaching tool. We found that students used the PDM to ground their mathematical representation and physical intuition of the thermodynamics transfer problem, and many participants reported that the activity was informative, enjoyable, and gave them a deeper physical understanding of Legendre transformations.

FK08: 9:40-9:50 a.m. Studying Response-Shift Bias in the CLASS with a Retrospective Study

Contributed – Ramesh Adhikari, Jacksonville University, 2800 University Blvd N, Jacksonville, FL 32211; radhikari@ju.edu

W. Brian Lane, Terry Ellis, Paul Simony, Jacksonville University

The Colorado Learning Attitudes about Science Survey (CLASS) is an important tool to assess shifts in students' beliefs and attitudes about physics during a physics course. Students enter the course with preconceptions about the nature of physics and expectations about how to learn it. Instructors hope that students complete the course with a favorable shift in their attitudes about physics, but pre-to-post-instruction results indicate that this is usually not the case. However, these results may contain response-shift bias due to students' changing reference frames. Studies of other evaluation tools have shown that administering a survey retrospectively (i.e., asking students to estimate their incoming attitudes at the end of a course) can reveal response-shift bias. By comparing traditional pre- and post-instruction responses with retrospective responses to the CLASS, we evaluate the presence and effect of response-shift bias in a variety of introductory and intermediate physics courses.

FK09: 9:50-10 a.m. TAs' Perceptions of Different Problem Types in Introductory Physics

Contributed – Melanie Good, University of Pittsburgh, 3941 Ohara St., Pittsburgh, PA 15260; melanie.l.good@gmail.com

Emily Marshman, Chandralekha Singh, University of Pittsburgh

Edit Yerushalmi, Weizmann Institute of Science

We examined graduate teaching assistants' (TAs') views about different types of introductory physics problems within the context of a semester-long TA training course. The type of problem chosen can emphasize learning goals for students such as learning physics content knowledge and expert-like problem-solving approaches. In this investigation, TAs were given several problem types for the same physics scenario. The problem types differed in the extent to which they required students to use expert-like problem-solving approaches, such as describing the problem in physics terms, planning sub-problems, etc. TAs were asked to list pros and cons of each problem type, to rate the problem types in terms of their instructional benefit and level of challenge for their students, and describe when and how often they would use the problem types in their own classes if they had complete control of teaching the class. The same data collection tools were used in a previous investigation of faculty members' beliefs about problem types allowing for comparisons between the beliefs of TAs and faculty members. We find that most TAs stated that they valued and were likely to use problems that were broken into sub-problems more than a context-rich problem, designed to require students to use expert-like problem-solving approaches. Many TAs explained their reluctance to use the context-rich problem in that it is unclear and time-consuming to students. These findings differ from former study findings regarding faculty – they valued context-rich problems, yet would not use them on tests to avoid putting stress on students. We thank the National Science Foundation for support.

FK10: 10-10:10 a.m. The Impact of the NSF S-STEM Program

Contributed Kevin M. Lee, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230; klee6@unl.edu, kelee@nsf.gov

Connie K. Della-Piana National Science Foundation

The National Science Foundation Scholarships in Science, Technology, Engineering and Mathematics program (NSF S-STEM) is a longstanding program that provides scholarships and support structures for STEM students who are of high-ability (or high-potential) and are low-income students with demonstrated financial need. This presentation will describe the evidence for the significant impact of the S-STEM program. We will also discuss the recent evolution of S-STEM program toward greater flexibility and educational research. Examples from the portfolio that include Physics and Astronomy students will be provided.

FK11: 10:10-10:20 a.m. The Interaction Between Physics Learning and Interdisciplinary Learning*

Contributed – Jill A. Marshall, University of Texas, 1 University Station D5700, Austin, TX 78712; marshall@austin.utexas.edu

Jay Banner, University of Texas

Hye Sun You, Michigan State University

In instructional paradigms such as project based instruction and cornerstone design, contextualized interdisciplinary problems serve as an introduction that motivates and facilitates further learning in individual disciplines. In others, interdisciplinary challenges serve as capstones, where prior learning is applied. I will report an investigation of the relationship between learning in individual disciplines, e.g., physics, and the development of interdisciplinary understanding (the ability to address problems requiring knowledge and practices from multiple disciplines for their solution) in the context of an environmental science class on sustainability. The physics covered includes energy transfer through radiation and convection, thermodynamics, and orbital motion Our population included science, engineering, and non-STEM majors, allowing us to probe the interaction between previous disciplinary learning and the development of interdisciplinary understanding. To facilitate this study we developed an instrument measuring disciplinary and interdisciplinary learning as separate constructs, and used confirmatory factor analysis to verify its structure.

*Support by a University of Texas Collaborative Teaching Grant.

FK12: 10:20-10:30 a.m. Teaching Model Making and Mode Breaking Skills with Direct Measurement Videos

Contributed – Matthew Ted Vonk, University of Wisconsin River Falls, 110 Bank St SE #2303, Minneapolis, MN 55414; matthew.vonk@uwrf.edu

Peter Bohacek Pivot Interactives SBC

For this study, we were curious to see if students could develop two science process skills using interactive high resolution direct measurement videos. The first skill, model making, is the ability to analyze a phenomenon in a way that produces a quantitative multimodal model. The second skill, model breaking, is the ability to critically evaluate if the behavior of a system is consistent with a given model. For this work, students interacted with video tools that allowed them to vary important parameters within the video that they were analyzing. This was accomplished by video recording slightly different versions of the same experimental scenario where each version had a unique set of parameter values. The videos were then brought together to form a multidimensional matrix of videos that students could explore in ways that are similar to the ways that they can explore with physical equipment.

Session FL: Phys21

Location: CC - Breakout 9
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Graduate Education in Physics
Date: Wednesday, July 26
Time: 8:30–9:30 a.m.

Presider: Aaron Titus

FL01: 8:30-9 a.m. How Can We Implement Phys21 Recommendations? Case Studies from Exemplary Programs*

Invited – Stephanie Chasteen, Chasteen Educational Consulting, 247 Regal St., Louisville, CO 80027; stephanie@chasteenconsulting.com

As part of the Joint Task Force on Undergraduate Physics Programs

(J-TUPP), I was commissioned to develop a series of "case studies" of exemplary programs: Undergraduate physics programs that had implemented significant activities to prepare their physics students for diverse careers. The varied approaches used by these programs are inspirational. Some programs were very intentional about focusing on student experience, others focused on curricular innovations, embraced experimentation and continuous improvement, or focused on novel and exciting science. In this talk I will share what these philosophies looked like in practice, including particularly transportable ideas and processes (e.g., assessment committees, strong public relations, strategies for the introductory course, career seminars). In this talk, you will learn about the strategies used in this program and how they might inform work at your home institution.

*This project is supported by the NSF under DUE # 1540570.

FL02: 9-9:30 a.m. PHYS21: Preparing Physics Students for 21st Century Careers*

Invited – Paula Heron, University of Washington, 3910 15th Ave. NE, Department of Physics, Seattle, WA 98195-1560; pheron@uw.edu

Physics majors pursue a wide range of careers after graduation with very few ending up in academia. Nevertheless, most physics programs appear to be designed with academic careers in mind. In order to better support all undergraduate physics students, the AAPT and APS formed a joint task force (JTUPP) to examine the employment landscape, understand the strengths and weakness of typical physics major preparation, and identify exemplary programs that ensure that all of their students are well prepared to pursue a wide range of career paths. The findings are contained in the report "PHYS21: Preparing Physics Students for 21st Century Careers." The report describes the skills and knowledge that undergraduate physics degree holders should possess to be well prepared for a diverse set of careers and makes recommendations intended to help departments and professional associations support student career preparation.

*Supported by the National Science Foundation through Grant No. 1540570.

Session FM: Research on Physics Teacher Preparation

Location: CC - Breakout 3
Sponsor: Committee on Teacher Preparation
Co-Sponsor: Committee on Research in Physics Education
Date: Wednesday, July 26
Time: 8:30–10:20 a.m.

Presider: John Stewart

FM01: 8:30-9 a.m. Recruiting Teachers in High Need STEM Fields*

Invited – Monica Plisch, American Physical Society, 1 Physics Ellipse, College Park, MD 20740; plisch@aps.org

Michael Marder, Casey Brown, University of Texas at Austin

The United States faces persistent shortages of appropriately prepared middle and high school STEM teachers in high needs fields, particularly physics, chemistry, and computer science. The American Physical Society, American Chemical Society, Computing Research Association and Mathematics Teacher Education Partnership surveyed over 6000 current and recent majors in our disciplines. Our recommendations to professional societies and disciplinary departments are to: (1) Promote middle and high school teaching with undergraduate majors and graduate students (2) Support high quality academic programs that prepare students for STEM teaching, and expand good models to more universities, (3) Expand programs that provide financial and other support for students pursuing STEM teaching, (4) Advocate for increases in annual compensation, including summer stipends, on the order of $5K--$25K for teachers in the hardest to staff STEM disciplines, and (5) Support programs that improve the professional life and community of STEM teachers.

*This work was supported by the American Physical Society Panel on Public Affairs.

FM02: 9-9:30 a.m. A New Survey: Perceptions of Teaching as a Profession (PTaP)

Invited – Wendy K. Adams, University of Northern Colorado & Colorado School of Mines, 501 20th St., Greeley, CO 80639; wendy.adams@unco.edu

Monica Plisch, American Physical Society

Heather Taffe, University of Northern Colorado

Taylor Plantt, Greeley West High School

Kristine Callan, Colorado School of Mines

To help with early identification of future teachers and to better understand the impact of the PhysTEC Project, we have been developing the survey of Perceptions of Teaching as a Profession (PTAP) to measure students' views of teaching as a career, their interest in teaching, and the perceived climate of physics departments towards teaching as a profession. The instrument consists of a series of statements which require a response using a 5-point Likert-scale and can be easily administered online. We are in our second year of development and will report on large-scale statistical analyses of 900 student responses as well as a factor analysis that has identified nine strong categories of student responses. We will share these categories, preliminary results, the latest version of the instrument and the newly developed scoring sheet.

FM03: 9:30-10 a.m. Development of the Physics Teacher Education Program Assessment (P-TEPA)*

Contributed – Stephanie Chasteen, Chasteen Educational Consulting, 247 Regal St., Louisville, CO 80027; stephanie.chasteen@colorado.edu

Rachel Scherr, Scherr & Associates

Monica Plisch, American Physical Society

There is a severe shortage of qualified secondary physics teachers in the United States: 63% of all high school physics teachers lack either a degree in physics or teacher certification. A fundamental cause is that few physics departments are engaged in the preparation of physics teachers, due to lack of professional rewards, negative attitudes about teaching among faculty, difficulty working with the college of education, and other factors. Despite such barriers, each year a select few physics departments manage to graduate five or more qualified physics teachers annually from their teacher preparation programs. What can we learn from such "thriving programs" to help other programs emulate such results? In this talk we will present our initial results from development and validation of the Physics Teacher Education Program Assessment (P-TEPA). The P-TEPA is a detailed rubric – based on prior work in the field – which systematically characterizes elements that typify such "thriving programs". The P-TEPA is intended to be used by researchers and program leaders to understand and improve physics teacher preparation programs.

*Development of the P-TEPA is supported by the NSF under DUE # 0808790, and is directed by the external evaluation team (Chasteen Educational Consulting) of the Physics Teacher Education Coalition (PhysTEC).

FM04: 10-10:10 a.m. Characterizing Interactions in Learning Assistant Preparation Sessions*

Contributed – Ryan J. Zamora, Texas State University, 749 North LBJ, San Marcos, TX 78667-0747; rz1030@txstate.edu

Jessica Conn, Shahrzad Hessaaraki, Aaron Collins, Eleanor Close, Texas State University

The Learning Assistant (LA) program structure at TXST is informed by the theory of Communities of Practice, which describes learning as an ongoing process shaped by participation in overlapping communities. Identity as nexus of multimembership is defined by the work of reconciling forms of membership in different communities. We are interested in how participation in the program influences LAs' identity both as physics students and as physics teachers. For three semesters, we have been video recording LA preparation sessions. These weekly meetings provide the opportunity for community support as the LAs and faculty reflect on in-class teaching practices as well as on the content of the physics activities they are preparing to facilitate. In this study, we analyze the video using an observational protocol to characterize LA and faculty interactions. We find that during these prep sessions LAs

Plenary Session

Location: CC - Event Center II
Date: Wednesday, July 26
Time: 10:30 a.m.-12 p.m.

Presider: Gordon Ramsey

The Effective Force, by *Francis Slakey,* APS/Georgetown University

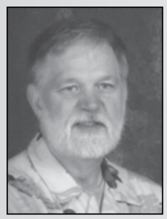
Francis Slakey

After a decade of crisscrossing the globe and witnessing social challenges, I restructured my physics classes at Georgetown University to enable students to take meaningful action on social issues. One powerful lesson has emerged: a science student, inspired by a sense of social purpose, is one of the most effective forces we have to build a better world. I'll review a few illustrative recent examples of student projects including: establishing a company that addresses invasive species, advocating to the federal government to promote pre-med "shadowing", and making a viral video to generate industry action on microfiber pollution.

2017 Homer Dodge Distinguished Service Citations Presented to:

Joseph Kozminski

Duane Merrell



William Reitz

Paul Stanley

Toni Sauncy

engage in a variety of interactions including physics-oriented, teaching-oriented, reflective, and social.

*Supported by: NSF #1557405, #1431578, #0808790, and the Halliburton Foundation.

FM05: 10:10-10:20 a.m. Nexus of Multimembership as Source of Physics Teacher Identity*

Contributed – Jessica Conn, Texas State University, 2011 E. 6th St Apt 1312, Austin, TX 78702; jconn@txstate.edu

Aaron C. Collins, Shahrzad A. Hesaaraki, Ryan J. Zamora, Eleanor W. Close, Texas State University

The Learning Assistant (LA) program structure at TXST is informed by the theory of Communities of Practice, which describes learning as an ongoing process shaped by participation in overlapping communities. Identity as nexus of multimembership is defined by the work of reconciling forms of membership in different communities. We are interested in how participation in the program influences LAs' identity both as physics students and as physics teachers. Our analysis suggests that engagement in the LA program increases LAs' sense of competence both in physics content and in the practice of engaging in the physics community. The LA program creates an overlap between the community of STEM majors and that of physics instructors, such that LAs are members of both communities and the shared practices improve the functioning of each one. By participating in multiple communities, LAs continuously re-negotiate their identities in ways that encourage development of positive teacher identity.

*NSF #1557405, #1431578, #0808790, and the Halliburton Foundation

TOP05: PERTG Town Hall

Location: CC - Event Center II
Sponsor: AAPT/PERTG
Date: Wednesday, July 26
Time: 12.–1:30 p.m.

Presider: Natasha Holmes

Session GA Creating Inclusive Diverse Classrooms

Location: CC - Breakout 4
Sponsor: Committee on International Physics Education
Co-Sponsor: Committee on Diversity in Physics
Date: Wednesday, July 26
Time: 1–3 p.m.

Presider: Carolina Alvarado

GA01: 1-1:30 p.m. Making Graduate Education in Physics More Inclusive

Invited – Geraldine L. Cochran, Rutgers University, Douglass Project Building - Chem Annex, 50, Bis,hop Street New Brunswick, NJ 08901; moniegeraldine@gmail.com

Theodore Hodapp, Erika E.A. Brown, American Physical Society

Historically, access to education in the U.S. has not been equitable. Furthermore, intersectionality, the interaction of multiple identities, results in educational experiences that vary widely for diverse groups of students with implications for both the retention of current students and the recruitment of future students. In this talk, current literature on inclusion and intersectionality in graduate physics programs will be discussed. To better understand barriers to ethnic/racial minority students participating in graduate education a study has been conducted through the APS Bridge program, a program designed to increase the number of ethnic/racial minorities earning PhDs in physics. In this study, we analyzed student responses to an application question regarding why they chose not to apply to graduate physics programs. To further understand the barriers identified in the first phase of this study, we interviewed participants in the 2016 Cohort of the APS Bridge program. This work will be presented.

GA02: 1:30-2 p.m. Día de la Física: Working with Diverse Student Populations

Invited – Ximena C. Cid, California State University, Dominguez Hills, 1000 E. Victoria St., Dept. of Physics, Carson, CA 90747-0005; ximena.c.cid@gmail.com

In October 2016, the National Society of Hispanic Physicists (NSHP) and UC Irvine held a one-day conference in conjunction with the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) annual conference. Día de la Física invited students from local Southern California institutions, including California State Universities (CSUs), and Universities of California (UCs) to participate in faculty seminars and lab tours. They were provided lunch and other refreshments throughout the day and any non-local students participating in the SACNAS conference were then transported to Long Beach, CA hotels. The goal of the Día de la Física was not only to introduce students to various subfields of physics, but also to provide an environment to foster mentoring and networking amongst participants and faculty. This session will highlight some successes as well as areas of improvement for future conferences.

GA03: 2-2:30 p.m. Using Student Reflection and Instructor Feedback to Combat Weed-out Culture

Invited – Dimitri R. Dounas-Frazer, University of Colorado Boulder, Department of Physics 390 UCB, Boulder, CO 80309-0390; dimitri.dounas-frazer@colorado.edu

Twenty years ago, Seymour and Hewitt described many reasons why science students switch majors or drop out of college altogether. They identified weed-out culture as particularly salient to attrition of men of color and all women. According to Seymour and Hewitt, weed-out culture is partially characterized by professors' lack of personal attention to students' academic challenges. To combat this culture, my colleagues and I developed an activity through which students submit weekly reflections about their learning. In turn, instructors provide personalized responses to each student, ideally positioning themselves as people on whom students can depend while also encouraging students to take responsibility for their own learning. In this presentation, I characterize student and instructor engagement in the activity, and I discuss how it may unintentionally reinforce ableist and racist ideologies that locate "fault" within students rather than educational structures. Finally, I describe a vision for student-teacher dialogue about institutional barriers to learning.

Session GB: Panel – Make, Play, Learn

Location: Marriott - Covington Ballroom I
Sponsor: Committee on Physics in Pre-High School Education
Date: Wednesday, July 26
Time: 1–3 p.m.

Presider: Gene Easter

Join in the fun as we construct science equipment exemplifying one of the most effective ways for K-12 students to learn: Active Engagement. Our crackerjack panel will kick-off this round-robin style share-a-thon with engaging "make n take" projects complete with excellent support activities. Participants will construct their own apparatus with the materials provided. Also, participants are highly encouraged to contribute their favorite classroom activities. Please bring sufficient materials and instructions to share with 25 other teachers.

Panelists:

Bill Reitz, Hoover High School, North Canton, OH

Elaine Gwinn, Rhinebeck, NY

Kathy Holt, Livingston, LA

Duane Merrell, Brigham Young University

Session GC: Panel – Public Affairs / Physics Teacher Recruitment

Location: Marriott - Covington Ballroom II
Sponsor: Committee on Professional Concerns
Co-Sponsor: Committee on Teacher Preparation
Date: Wednesday, July 26
Time: 1–3 p.m.

Presider: Kelli Gamez Warble

In 2013, the National Task Force on Teacher Education reported that "the need for qualified physics teachers is greater now than at any previous time in U.S. history." Many high schools have stopped offering physics because they cannot find qualified teachers. A number of universities have adopted innovative solutions to address this teacher shortage and some have significantly increased the number of physics teachers they graduate. Find out about the strategies they have employed and how they have succeeded.

Panelists:

Monica Plisch, APS

Duane Merrell, Brigham Young University

Rebecca Vieyra, AAPT

Session GD: Panel – Professional Skills for Graduate Students

Location: Marriott - Covington Ballroom III
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Graduate Education in Physics
Date: Wednesday, July 26
Time: 1–3 p.m.

Presider: Daryl McPadden

This interactive panel focuses on developing professional skills for graduate students and other early-stage researchers. This session will address professional concerns brought up by graduate students during the past Crackerbarrels/Topical Group Discussions. Topics covered may include: preparing for careers after graduate school, becoming integrated with the community, developing research skills, and disseminating your work.

Panelists:

Stamatis Vokos, Cal Poly San Luis Obispo

Marcos D. Caballero, Lansing, MI

Session GF: Current Space/ Astronomy/Physics News Used in the Classroom

Location: CC - Breakout 5
Sponsor: Committee on Physics in Two-Year Colleges
Date: Wednesday, July 26
Time: 1–1:30 p.m.

Presider: John Cise

GF01: 1-1:10 p.m. Student Submission of News Articles for Extra Credit

Contributed – Richard Gelderman, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101-1077; gelderman@wku.edu

Once every week of the semester, the students in my introductory astronomy course are encouraged to submit news articles for extra credit. We talk about each news item immediately after the extra credit submissions are collected, occasions are often the best moments of the semester. To receive extra credit, all that is required is that the source and date of the news story is clearly indicated and that they list the section(s) and/or page(s) in our text where that topic is presented. The process is designed to be easy for the students and easy for the instructor.

GF02: 1:10-1:20 p.m. From Conceptual Frameworks to Mental Models for Astronomy

Contributed – David Pundak, Kinneret College, Ashdot Yaacov Ichud, Jordan Valley, Israel 15155; dpundak@gmail.com

Ido Lieberman, Western Galilee College

Miri Shacham, ORT Braude College

This research investigated conceptual frameworks and mental models for astronomy held by college students, with regard to four areas of astronomical knowledge: 'sky observations', 'the earth and its orbit', 'the solar system' and 'stars', using the Conceptual Frameworks in Astronomy (CFA) new research instrument (Pundak, 2016). The responses of 537 students from three colleges were classified according to four mental models: pre-scientific, geocentric, heliocentric and stellar/scientific. The research findings indicate the existence of significant differences between the four mental models. Most of the students adopted a mix of these models and employed different conceptual frameworks with regard to different astronomical phenomena. Students with a scientific engineering background tended to employ the stellar/scientific model more in comparison with students from liberal arts colleges. The stellar/scientific model is an advanced model, which includes coherent astronomical conceptual frameworks. The research identified three variables: 'physics background', 'mean academic grade' and 'academic discipline' that contribute to the adoption of the stellar/scientific model.

GF03: 1:20-1:30 p.m. UWRF Astrophysics Research: Cosmic Opportunities for TYC Students and Beyond

Contributed – Jim Madsen, UW-River Falls, 410 South Third Street, River Falls, WI 54022; United States james.madsen@uwrf.edu

Lowell McCann, Surujhdeo Seunarine, UW-River Falls

A challenge of integrating undergraduates into research is the need for foundational skills and knowledge. At UWRF, we have successfully involved students with as little as one year of introductory physics and no prior programming experience in national and international research projects. The key is to develop appropriate projects and provide just-in-time training to develop programming proficiency and other skills needed to carry out meaningful research. This talk will describe how we utilize our connections with the South Pole IceCube Neutrino Observatory and neutron monitors to provide 10 week summer astrophysics research opportunities. Our approach enables us to provide motivating research experiences earlier in students' college careers, and thus work with a broader array of students, including those from two-year colleges.

Session GG: Panel – Learning Outcomes and Assessment in the IPLS Course

Location: CC - Breakout 6
Sponsor: Committee on Physics in Undergraduate Education
Date: Wednesday, July 26
Time: 1–3 p.m.

Presiders: Patricia Soto and Benjamin Geller

The goal of the panel is to engage IPLS instructors in a wide conversation on the design, implementation, and adoption of IPLS course assessment tools. The session will include discussion of instruments (or potential instruments) that measure student learning in the cognitive, affective, and psychomotor domains, and presenters will describe initial challenges and successes in attempting to implement such assessments. While much work has already been done to develop engaging and authentic IPLS curricula, we as a community need to evaluate how best to assess the learning goals of IPLS courses. We expect that the panel discussion will contribute to sustainable course transformation and validation across institutions.

GG01: 1-3 p.m. Integrated Introductory Science for Major: Assessment of Outcomes

Panel – Scot Gould, Claremont McKenna, Pitzer, Scripps Colleges. W.M. Keck Science Center, 925 N. Mills Ave., Claremont, CA 91711-5916; sgould@kecksci.claremont.edu

Accelerated Integrated Science Sequence, (AISS) is a year-long double course for students majoring in the natural sciences at the W.M. Keck Science Dept. of Claremont McKenna, Pitzer, and Scripps colleges. AISS has been a major recruiting tool by the colleges. AISS satisfies the requirements for completing introductory biology, chemistry, and physics by integrating topics from these disciplines along with topics from calculus and computer science. Since most students in this program will not major in physics, we have attempted to assess the impact of the program in comparison with the students who completed the introductory sciences through traditional discipline specific courses using a variety of metric. We will report our preliminary results related to student retention, discipline selection, performance both immediately after completing AISS, at graduation and post-graduation.

GG02: 1-3 p.m. Learning Outcomes and Assessment of Pre-Health Student Projects

Panel – Nancy Donaldson, Rockhurst University, 1100 Rockhurst Road, Kansas City, MO 64110; nancy.donaldson@rockhurst.edu

At Rockhurst University, we have made a concerted effort to help our students see the wonderful value of taking physics through a focus on the application of physics principles to students' career goals in the medical and healthcare field. Our student learning objectives address the relevance of physics to students' pre-health interests, communication skills, and integration of concepts in the development of student projects. In this session, student projects in Physics for the Life Sciences will be shared with examples of student presentations and assessment results.

GG03: 1-3 p.m. Impact of IPLS Course Materials on Attitudes of Pre-health Students Toward Physics Instruction*

Panel – Elliot Mylott, Portland State University, 1719 SW 10th Ave. Room 134, Portland, OR 97201; emylott@pdx.edu

Warren Christensen, North Dakota State University

Ralf Widenhorn, Portland State University

We developed modular multimedia educational material for a reformed pre-health focused IPLS course at Portland State University. The modules include videos of biomedical experts detailing the core physics behind devices in clinical use. Original text and online homework problems expand on the material presented by the biomedical experts. Our research on the course explored (1) whether students' opinions on the relevance of physics to medicine was impacted by the biomedical focused physics instruction, (2) how that influenced their interest in physics, and (3) whether students in the IPLS course were able to make conceptual links between physics content and biomedical technology. Shifts in attitudes were collected through student surveys in both the reformed IPLS course and a concurrent traditional course. Interviews from students in the IPLS course were used to elucidate responses from the surveys. Conceptual understanding and biomedical contextualization of physics topics by students in both the traditional and reformed courses were assessed through open-ended prompts using diagrams often encountered in physics courses.

*This work was supported by a grant (DUE-1431447) from the National Science Foundation.

GG04: 1-3 p.m. Physics for Life Science Majors: A 1-Semester Approach?

Panel – Jason Puchalla, Princeton University, Department of Physics, Jadwin Hall, Princeton, NJ 08544-1098; puchalla@princeton.edu

Nationwide, courses in physics for life science majors have undergone substantial changes in the past decade. A primary objective of these changes has been to increase life science "appeal" while not compromising on valuable learning goals. Achieving this objective is complicated by the need to serve students with a broad range of educational backgrounds (e.g. no background, AP credit, summer programs) and widely varying expectations (e.g. premedical preparation, course requirement for major, general interest in subject). Factors such as these coupled with ongoing modifications to medical school requirements have led us to investigate a survey-style, 1-semester course intended to better meet the needs of students at Princeton University. Here we present the course structure, pedagogy and assessment results of the 2017 class offering. In this third offering, class enrollment reached capacity (45 + wait list) and included students from all life science departments.

GG05: 1-3 p.m. Assessment of Learning Outcomes in a Competency-based IPLS Course

Panel – Nancy Beverly, Mercy College, 555 Broadway, Dobbs Ferry, NY 10522; nbeverly@mercy.edu

At Mercy College the course grades for students in the IPLS course are based directly on the assessment of their competence in the learning outcomes, which incorporate students' integration of physics with life phenomena within larger critical skills such as inquiry, investigation, modeling, quantitative analysis, communication, and creativity. The curriculum is project-based with students defining and solving their own problem scenarios, so the assessment is aligned with student guidelines and self-assessment checklists as well as the learning outcomes. There is tension between the assessment providing detailed enough feedback for effective revision of individual project efforts and time management issues. The learning outcomes, the supporting curriculum, and the assessment itself are continually re-evaluated as part of the reiterative assessment process. As student weaknesses are unearthed, curricular and learning outcomes changes are made, followed by a new assessment, only to uncover new areas rising to the surface needing attention.

GG06: 1-3 p.m. Learning Outcomes and Assessment in the IPLS Course

Panel – Brian Jones, Colorado State University Department of Physics, Colorado State University, 1875 Campus Delivery Fort Collins, CO 80523; bjones@lamar.colostate.edu

In the past year, we have changed the style of instruction in our large IPLS course to include small group work guided by learning assistants. This has measurably increased student engagement and has allowed us to significantly increase the time spent on applications of physics concepts to life science topics. In this talk, I'll share some of the results we've achieved and some of the lessons that we've learned.

Session GH: Upper Division Undergraduate

Location: CC - Breakout 7
Sponsor: AAPT
Date: Wednesday, July 26
Time: 1–3 p.m.

Presider: Paul Walter

GH01: 1-1:10 p.m. Equal Signs in EM: Homework vs. Solution Manuals

Contributed – Dina Zohrabi Alaee Kansas State University, 116 Cardwell Hall, 1228 N. 17th St., Manhattan, KS 66506-2601; dindinzalaee@gmail.com

Natasha Graham, Eleanor C. Sayre, Kansas State University

Kellianne Kornick, Scott V. Franklin, Rochester Institute of Technology

The equals sign carries different conceptual meaning depending on how it is used; this meaning is deeply tied to cultural practices in problem solving in physics. We use symbolic forms to investigate the conceptual and cultural meanings of the equals sign across physics contexts, from textbooks to student work to classroom video and from introductory physics to senior-level quantum. We built and validated a rubric to classify the ways that physics students and textbook authors use the equals sign in written work. The data for this study comes from students' written homework in an upper-division electrostatics course, compared to Griffiths' solution manual for the same course. Our categories are causality, assignments, definitional, balancing, and math. We show that the patterns of equals sign use for students and the solution manual are comparable on comparable problems, but for students' problems that are not drawn from the textbook, other patterns emerge. This suggests that the problem statement affects the patterns of students' equals sign use.

GH02: 1:10-1:20 p.m. Equals Signs in Students' Work in EM

Contributed – Natasha Graham, Kansas State University, 536 E. Poplar ST., Olathe, KS 66061; Nlgraham@ksu.edu

Dina Zohrabi Alaee, Eleanor C Sayre, Kansas State University

Kellianne Kornick, Scott V. Franklin, Rochester Institute of Technology

The equals sign has a different conceptual meaning that depends on how it is used, and this can show the cultural significance of different practices in solving problems in physics. Using symbolic forms to understand the equals signs, we look at different contexts, including textbooks and students' homework for introductory level physics up to senior level quantum. To better classify and compare equals signs, a rubric was developed to categorize them into five categories: causality, assignment, definitional, balancing, and math. With this, we are able to look for patterns and discern methods used by students in an upper-level electrostatics course by looking at homework questions and the solutions given by the students. The data from the homework can then be compared to video data of students solving problems to see other patterns or thoughts that don't translate well onto paper.

GH03: 1:20-1:30 p.m. "Looking Ahead" as an Extended Read out Strategy in EM

Contributed – Bahar Modir, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; bahar@phys.ksu.edu

Eleanor C. Sayre Kansas State University

As part of a larger project to investigate how upper-division students solve mathematically intense problems, we use coordination class theory to describe how students connect physical scenarios with mathematical insight. Within coordination class theory, students read information out of problem statements, connecting the specifics of the problem with generalized conceptual schemata (the "coordination class") in a causal net. While previous research using coordination classes has focused on identifying particular coordination classes or details of the causal net, our research focuses on an extended readout strategy, which we call "looking ahead." To characterize the mechanism of looking ahead, we study students' problem solving with separation of variables and Taylor series expansions. When students look ahead in a problem, their mathematical and physical insight can help them avoid time consuming calculations. In this talk, I will discuss the structure of looking ahead and illustrate it with video-based classroom data.

GH04: 1:30-1:40 p.m. Student-Centered Activities with Vector Field Maps and Scalar Potential Surfaces

Contributed – Robyn L. Wangberg, St. Mary's University of Minnesota, 700 Terrace Heights Box #32, Winona, MN 55987; rwangber@smumn.edu

Elizabeth Gire, Oregon State University

Aaron Wangberg, Winona State University

Understanding, visualizing, and working with multivariable functions is necessary, and often a stumbling block, for students in upper-division and applied physics courses. An example is the three-dimensional electric field and the corresponding scalar electric potential. As part of the Raising Physics to the Surface project we have designed tangible, transparent, dry-erasable surfaces representing the electric potential for a quadrupole charge distribution at three different constant z slices. This talk shares how we used these materials, along with a vector field map at z=0, to help students gain a geometric understanding of the relationship between these vector and scalar functions.

GH05: 1:40-1:50 p.m. Physicists' Use of Raising Calculus Materials in Mathematical Methods

Contributed – Aaron Wangberg, Winona State University, 8930 E 9th St., Winona, MN 55987; awangberg@winona.edu

Elizabeth Gire, Oregon State University

The Raising Calculus materials were developed four years ago to let math students explore the geometry underpinnings of differentiation and integration in multivariable calculus as well as connect mathematical ideas across representations. Almost immediately upon their release, physicists began adopting and using the materials in their middle-division physics courses. In this talk, we'll report how the materials have been utilized in mathematical methods courses – including how the features 'cooked-in' to the math materials have helped or hindered instruction in the physics world. Lastly, we'll report how these lessons are being incorporated into a new project, Raising Physics to the Surface.

GH06: 1:50-2 p.m. Light, Imaging, Vision: An Interdisciplinary Undergraduate Course and New Textbook*

Contributed – Philip Nelson, Univ Pennsylvania, Physics DRL / 209 South 33d St., Philadelphia, PA 19104; nelson@physics.upenn.edu

Students in physical and life science, and in engineering, need to know about the physics and biology of light. In the 21st century, it has become increasingly clear that the quantum nature of light is essential both for the latest imaging modalities and even to advance our knowledge of fundamental processes, such as photosynthesis and human vision. But many optics courses remain rooted in classical physics, with photons as an afterthought. I'll describe a new undergraduate course for students in several science and engineering majors, that takes students from the rudiments of probability theory to modern methods such as fluorescence imaging and Förster resonance energy transfer. After a digression into color vision, students then see how the Feynman principle explains the apparently wavelike phenomena associated to light, including applications like diffraction limit, subdiffraction imaging, total internal reflection and TIRF microscopy. Then we see how scientists documented the single-quantum sensitivity of the eye seven decades earlier than `ought' to have been possible, and finally close with the remarkable signaling cascade that delivers such outstanding performance. A new textbook, to be published in April 2017, allows others to replicate this course.

*Partially supported by the United States National Science Foundation under Grant PHY-1601894.

GH07: 2-2:10 p.m. Students' Problem Solving: Translation Between Multiple Representations

Contributed – Nandana J. Weliweriya Liyanage, Kansas State University, Dept. of Physics, 116 Cardwell Hall, Manhattan, KS 66506; nandee122@ksu.edu

Tra Huynh, Eleanor Sayre, Kansas State University

As part of a larger project to investigate processes of problem-solving in upper division classrooms, we investigate how students translate between representations while solving problems. Data for this study is drawn from upper-division Mechanics and Electromagnetism I courses, where students engage in group problem-solving sessions and individual oral exams. We do the moment-by-moment analysis of videos to see what representations students use, how they use them, and how students switch between them. Students frequently use diagrams, gestures, algebraic, and verbal representations. They use these representations to recorded their ideas, make sense of scenarios, and communicate with an interlocutor. In this talk, we present our preliminary findings of student translation patterns between representations.

GH08: 2:10-2:20 p.m. Coordinating Representations in Upper-Division Problem Solving

Contributed – Tra Huynh, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; trahuynh@ksu.edu

Nandana Weliweriya, Eleanor Sayre, Kansas State University

Mastering problem solving requires students to not only well understand and apply the physics concepts but also employ mathematics and various representations skillfully. We use Conceptual Blending to investigate students' representational use as they attempt to solve problems that coordinate multiple representations such as math, diagram, and kinesthetic. To better understand the pattern of students' use and switching among various representations, we focus on a case of one undergraduate student in an upper division Electromagnetic Field 1 course. By analyzing video data of his oral exam, we identify a chain of blends coupled to his representational use. We found that the student used some common and also individually specific representations to deal with the problems. The result gives an insight into the student's thought and the role of representations in problem solving.

GH09: 2:20-2:30 p.m. Investigating and Improving Student Understanding of Dirac Notation in the Context of a Three-Dimensional Vector Space

Contributed – Emily M. Marshman, University of Pittsburgh, 209 Allen Hall, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We discuss an investigation of student difficulties with Dirac notation in the context of a three-dimensional vector space and the development and evaluation of a research-based Quantum Interactive Learning Tutorial (QuILT) to improve student understanding of these concepts. We find that many upper-level undergraduate students in quantum mechanics courses have difficulties with Dirac notation even in the context of a three-dimensional vector space. The QuILT uses analogical reasoning and builds on students' prior knowledge of three-dimensional vectors in the familiar context of introductory mechanics to help students build a coherent understanding of Dirac notation in three dimensions before transitioning to the quantum mechanical context. We summarize the development of the QuILT and findings from its evaluations. We thank the National Science Foundation for support.

GH10: 2:30-2:40 p.m. A Toy Model for the Strong Nuclear Interaction

Contributed – Jarrett L. Lancaster, Roanoke College, 221 College Ln., Salem, VA 24153; jlancaster@roanoke.edu

Of the four known fundamental forces in nature, it is noteworthy that only gravity and electromagnetism are normally discussed at the undergraduate level. Admittedly, a precise description of the strong and weak nuclear forces is quite involved. In this talk, I present a framework for introducing several intriguing properties of the strong interaction (including quark confinement and formation of flux tubes) that requires only a working knowledge of intermediate-level electromagnetism. By making use of the analogy between the (relatively) simple behavior of electromagnetic fields described by Maxwell's equations and that of strong force fields governed by nonlinear field equations, it is possible to sidestep many of the technical hurdles that preclude a substantial discussion of the strong interaction in most undergraduate-level settings. I will give special attention to how this material could provide the basis for a fascinating "special topic" at the end of a junior-level course on electromagnetism.

GH11: 2:40-2:50 p.m. Easy Examples of Emerging Entanglement

Contributed – Daniel V. Schroeder, Weber State University, 2508 University Circle, Ogden, UT 84408-2508; dschroeder@weber.edu

Why save quantum entanglement for advanced courses? We can easily introduce examples of entangled wave functions in any course that covers wave functions, including modern physics courses and many introductory physics courses. In this talk I will show some pictorial examples of how entangled wave functions arise naturally when two quantum particles interact with each other. While quantitative treatments of these interacting systems require numerical methods, the qualitative results are easy to understand and lend themselves to useful conceptual exercises.

http://physics.weber.edu/schroeder/

GH12: 2:50-3 p.m. Assessing and Developing Mathematical Reasoning in Upper-Division Physics*

Contributed – Michael E. Loverude, California State Univ Fullerton, Dept of Physics MH611, Fullerton, CA 92834; mloverude@fullerton.edu

As part of an NSF-supported research and curriculum development project, we have studied student reasoning with math across several upper-division physics courses, including mathematical methods. We take the position that the math methods course should go beyond procedural knowledge and emphasize quantitative reasoning skills valued by physicists, including checking units, limiting cases, and sketching. For this presentation, we describe a number of examples of skills of this nature, and make the claim that physics majors entering the upper-division need help in the developing these skills. Examples of student responses from written problems and interviews will be shown, as well as tasks intended to develop and assess such skills.

*Supported in part by NSF grant PHY#1406035.

Session GI: Effective Practices in Educational Technology

Location: CC - Breakout 8
Sponsor: Committee on Educational Technologies
Date: Wednesday, July 26
Time: 1–2:50 p.m.

Presider: Colleen Countryman

GI01: 1-1:10 p.m. Smartphone-based Stereoscopic Virtual Reality in Introductory Physics

Contributed – Joseph R. Smith, Dept. of Engineering Education; The Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; United States smith.10838@osu.edu*

Christopher Orban, Christopher Porter, The Ohio State University

The use of virtual reality (VR) in instruction has been difficult due to high-cost headsets or "caves", and the challenge of serving an entire student population with only one or a few such devices. This has changed with the advent of smartphone-based stereoscopic VR. Inexpensive cardboard headsets and smartphones already in students' pockets are the only elements needed for a virtual reality experience. We have designed short VR training sessions and have studied the utility of this training in the context of charge and electric fields in an introductory physics course at the Ohio State University. We compare performance on pre-post tests between students trained using VR, those trained using a video of the VR content, and those trained using static 2D images as in a traditional text. Although data are preliminary in this growing study, we comment on possible reasons for differences among student groups.

*Sponsored by Christopher Orban

GI02: 1:10-1:20 p.m. An Investigation on On-Off Line Hybrid Teaching Strategy

Contributed – Hana Jung, Seoul Soosong Elementary School, Changdongjugong APT 317-604, Headungro, Dobonggu, Seoul, 01421 South Korea puri1031@hanmail.net

Jhun Youngseok, Seoul National University of Education

The main purpose of elementary school physics education is to grow students' inquiry skill with which they could investigate nature phenomena and solve problems in the real world by the scientific way. Inquiry learning includes some processes such as making hypothesis, designing and performing experiments, collecting data, and making a conclusion. The effective way to develop inquiry skill of students in an elementary level is doing an experiment on authentic nature phenomenons. However, the school education system has trouble with lack of time, resource and non-individual environment as they conduct real experiment activities especially in the physic class. So, an online web-based teaching strategy has become a highlighted alternative way to complement an off-line physics experiment, covering weak points of it. Even though web-based teaching has good points, it also has shortcomings. Students have to face a machinery interface instead of human being, being lack of emotional and implicative touching with class colleagues and teacher. This study would investigate an on-off-line hybrid teaching strategy to take advantage of online and off-line teaching skill and minimize their shortcomings.

GI03: 1:20-1:30 p.m. Customizing Computer Coaches to Align with My Preferred Pedagogy

Contributed – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Ave., Platteville, WI 53818-3099; pawla@uwplatt.edu

Since 2010 I have been struggling to get my students to use a structured approach to problem solving in mechanics: the "System, Interactions, Model" or "S.I.M." strategy. One of the greatest difficulties is the fact that standard web-based homework systems are usually too limited to teach or even reinforce structured problem solving behavior among students. When I learned about the "C3PO" customizable computer coach software system developed in 2014 by the University of Minnesota Physics Education Research group*, I felt I had finally found a system that could be adapted to teach the SIM approach. Beginning in fall 2016 I have deployed 5 tailored computer coaches as part of the homework in my introductory mechanics courses. I will present what I learned from the process of customizing these coaches and how they have affected the performance of my students.

*K. Heller, E. Frodermann, L. Hsu, Q. Ryan and B. Aryal, 2014 AAPT Summer Meeting; http://groups.physics.umn.edu/physed/prototypes.html.

GI04: 1:30-1:40 p.m. Using Interactive Video Vignettes to Change Student Conceptions

Contributed – Jonathan A. Engelman, Kettering College, 3737 Southern Blvd., Kettering, OH 45429; jonathan.engelman@kc.edu*

Changing student conceptions in physics is a difficult process and has been a topic of research for many years. In this session, we will explore how two different structures of online videos changed student conceptions of Newton's second and third laws in distinct ways. A framework of elicit, confront, resolve, reflect was used to analyze student experiences with two Interactive Video Vignettes using a fully integrated mixed methods research design. While watching these videos, students experienced the framework in qualitatively different ways and these differences had unique impacts on conceptual change. Implications for design and structure of online videos will be discussed.

*Sponsored by Kathy Koenig

GI05: 1:40-1:50 p.m. Lab Without a Lab: An IOLAB-centered Alternative to the Traditional Lab Experience

Contributed – Stephen J. Mecca, Providence College, 1 Cunningham Square, Providence, RI 02908; smecca@providence.edu

Seth Ashman, Eric Gust, Nicole Boyd, Colby Anderson, Providence College

An alternative approach for the traditional General Physics lab (TL) is outlined. The Lab Without a Lab (LWL) includes hardware, software and procedures for an e-intensive yet hands-on active learning lab program and overcomes the need for lab space, an inventory of apparatus and the presence of an overseeing instructor. The hardware features the IOLAB and a component kit to enable a student to complete the experiments one finds in a TL lab program. The soft elements of the system include: flip videos for the usual instructor-led preparation that normally precedes a lab, a structured set of questions for each lab, and an innovative configured APP for student reports. Proof of concept has been effected and a full scale pilot to assess the LWL system versus the TL is planned for the 2017-2019. The impacts for TL physics, distance learning including MOOCs and for developing world rural schools are discussed.

GI06: 1:50-2 p.m. Interactive Video Vignettes Target Student Understanding of One-Dimensional Motion*

Contributed – Kathy Koenig, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; kathy.koenig@uc.edu

Robert Teese, Rochester Institute of Technology

Priscilla Laws, Dickinson College

Two new interactive video vignettes (IVVs), developed by the LivePhoto Physics Group, target student understanding of whether velocity and acceleration are negative or positive when an object changes direction or speed in one-dimensional motion. Each IVV allows the user to make a prediction about some motion and then use video analysis to develop a general rule for deciding whether an object is slowing down or speeding up. As part of our evaluation to determine the impact of the IVVs on student understanding of these ideas, each IVV was assigned as homework across 7 sections of introductory calculus-based physics. Concepts involved in the IVVs were later assessed using exam questions. Results will be presented that demonstrate the impact each IVV had on student understanding of one dimensional velocity and acceleration.

*Supported in part by a publishing partnership with Cengage and the NSF TUES Program (DUE #1123118 & 1122828).

GI07: 2-2:10 p.m. Project Accelerate: Blended SPOC Bringing AP Physics to Underserved Students

Contributed – Mark D. Greenman, Boston University, 868 Humphrey Street, Swampscott, MA 01907; greenman@bu.edu

Boston University is in the second year of a pilot program, Project Accelerate, partnering with 11 high schools in Massachusetts and West Virginia to bring a College Board approved Advanced Placement® Physics Small Private Online Course to schools not offering this opportunity to students. Project Accelerate students (1) outperformed peer groups in traditional AP Physics classrooms on the College Board AP Physics exam, and (2) were more inclined to engage in additional Science, Technology, Engineering and Mathematics (STEM) programs than they were prior to participating in Project Accelerate. Project Accelerate combines supportive infrastructures from the students' traditional school, a highly interactive private edX online course and small group laboratory experiences. Project Accelerate offers a replicable solution to a significant problem of too few underserved high school students having access to high quality physics education, resulting in these students being ill prepared to enter STEM careers and STEM programs in college.

GI08: 2:10-2:20 p.m. Programming a Computer-based Tutor for Rotational Dynamics*

Contributed – Vasudeva R. Aravind, Clarion University, 840 Wood Street, Clarion, PA 16214-1232; varavind@clarion.edu

Kevin Croyle Clarion University

Teaching and learning is only useful when students are able to retain knowledge, and apply the lesson learned at appropriate circumstances. Employing a tutor is well known to improve student learning and retention. However, due to the personnel time and costs involved, very few students are able to get access to a tutor. In this project, we attempted to program a computer-based tutoring system that will teach the students problem solving in rotational dynamics, and challenge them on the concepts learned. We used a user-friendly, non-technical programming tool called the Cognitive Tutor Authoring Tool (CTAT) hosted by Carnegie Mellon University. The goal of this tutor was to achieve robust student learning through appropriate hints and feedback in the process of solving a problem. We demonstrate that first year university physics students were able to achieve learning goals with this programmed tutor. We discuss the lessons learned from deploying this tutor, and possible future improvements.

*We acknowledge useful discussions with Dr. Vincent Van Aleven, Dr. Jonathan Sewall, and Dr. Cindy Tipper from Carnegie Mellon University.

GI09: 2:20-2:30 p.m. Modeling the Fluid Dynamics that Shape a River's Ecosystem

Contributed – Andre Bresges, University of Cologne, Gronewaldstr. 2, Cologne, NRW 50931 Germany; andre.bresges@uni-koeln.de

In Cologne's Competence Labs, we use a Game engine to model the Rhine River ecosystem. In the river, the fluid dynamics of the streaming water shapes a set of interconnected habitats. In the boundary layer at the riverbanks, plants, mossels and biofilms exist. Crabs and Barbels navigate the turbulent border areas of the river, harvesting the biomass of the boundary layer, while avoiding the high-flow area of the center stream. This is the habitat of sleek predators like pike and salmon that are able to navigate in the flow of 1 m/s to 3 m/s at the center while hunting for prey in the border areas. Data from the river authority is used to model this as virtual environment in Unreal Editor. No programming knowledge is required. The visible influence on the animal's movement is exploited and contextualized with physics experiments in the Competence Lab.

GI10: 2:30-2:40 p.m. Exploring Dark Matter Density Distributions in Introductory Courses

Contributed – Alex M. Barr, Howard Community College, 10901 Little Patuxent Parkway, Columbia, MD 21044; abarr@howardcc.edu

Kathleen Hamilton, Howard Community College

Dave Eidelman, Florida Institute of Technology

Galaxy rotation curves offer an accessible entry point for physics and astronomy students to begin learning about dark matter. At the introductory level, discussions of galaxy rotation curves often focus on how rotation curves offer support for the theory of dark matter and leave unaddressed questions of how the dark matter may be distributed throughout a galaxy and what percentage of galactic mass may be due to dark matter. In this presentation, I will share an Easy Java Simulation that allows students to experiment with different hypothetical dark matter density distributions as well as vary the amount of dark matter and the halo scale length. Students vary the density distribution and its parameters as they attempt to match the resulting theoretical rotation curve to actual experimental measurements for three different spiral galaxies, including the Milky Way. The simulation allows students to explore dark matter in more detail without getting tied down in tedious calculations.

GI11: 2:40-2:50 p.m. Online Inquiry Learning with Pivot Interactives

Contributed – Peter H. Bohacek, Pivot Interactives, 1897 Delaware Avenue, Mendota Heights, MN 55118; peter.bohacek@isd197.org

Matt Vonk University of Wisconsin-River Falls

Pivot Interactives are online learning activities that combine matrices of Direct Measurement Videos with interactive measurement tools, instructions, and data tables and graphing. The combination allows teachers to create complete web-based inquiry learning cycles. Students observe systems and events, develop questions, make predictions, then design and execute experiments to build knowledge, and report their findings—all in a single webpage. These activities can be used to teach or assess lab skills, or even conduct flipped learning for students to learn lab skills.

Session: PERC Bridging Session

Location: CC - Event Center II
Sponsor: AAPT
Date: Wednesday, July 26
Time: 2-3:30 p.m.

Presider: TBA

PERC01: 1:30–2 p.m. Quantitative Reasoning and Mathematical Modeling in an Introductory Calculus Sequence

Invited – Michael Oehrtman, Oklahoma State University

I will report on thematic results drawn from multiple studies of student learning in an introductory calculus sequence pertaining to the nature and roles of quantitative reasoning and mathematical modeling. We investigated calculus students' development of mathematical expressions and equations involving derivatives, definite integrals, and vector-valued functions to represent physical quantities and relationships between those quantities. The presentation will characterize the cognitive challenges that students encountered while constructing these models, how students resolved those challenges, and the resulting conceptual artifacts.

PERC02: 2–2:30 p.m. Student Understanding and Symbolization of Eigentheory

Invited – Megan Wawro, Virginia Tech

Linear algebra is a key course in students' undergraduate education across multiple STEM-related majors. Eigentheory is a conceptually complex idea that builds from and relies upon multiple key ideas in mathematics, and its application is widespread in mathematics and beyond. In this presentation, I will share research results from individual interviews regarding various ways that students in quantum physics courses reason about and symbolize eigenvectors and eigenvalues for a 2x2 matrix. I will also share an instructional sequence from the Inquiry-Oriented Linear Algebra curriculum created to support students' reinvention of change of basis and eigentheory, as well as how the two are related through diagonalization. Data from introductory linear algebra classes using this sequence will illustrate ways in which students build from their experience with stretch factors and directions to create for themselves ways to determine eigenvalues and eigenvectors for various 2x2 matrices.

TOP01: Avenues for Publishing in Astronomy Education

Location: CC - Breakout 9
Sponsor: Committee on Space Science and Astronomy
Date: Wednesday, July 26
Time: 2–3 p.m.

Presider: Tim Slater

Astronomy faculty are always looking for more information on how best to help their students learn. For those who want to share their best teaching ideas or classroom research results with the broader astronomy education and outreach community, there are a dizzying array of avenues available. In this 90-minute tutorial, you will have a chance to meet editors, reviewers, and authors for several publishing vehicles. We will provides insights about how to get your ideas disseminated through The Physics Teacher - AstroNotes, *ASTRO EDU, and* Journal of Astronomy & Earth Sciences Education, *among others pathways available to you.*

Session HA: Post-deadline Abstract

Location: CC - Breakout 1
Sponsor: AAPT
Date: Wednesday, July 26
Time: 3:30–4:40 p.m.

Presider: TBA

HA01: 3:30-3:40 p.m. Learning Gains Across Subgroups within PET High School Classrooms

Contributed – Jennifer R. Keil, University of Colorado Boulder, 171 Starlight Circle, Erie, CO 80303; jenniferkeil11@gmail.com

Nicole Schrode, Longmont High School

Rebecca Stober, Mapleton Expeditionary School of the Arts

Taylor Marino, Chayenne Theberge, University of Colorado Boulder

The Physics and Everyday Thinking High School (PET-HS) curriculum engages students in science practices of generating and defending claims using evidence and argumentation as a means of developing and formalizing physics principles. This study focuses on how students that are underrepresented or under performing in traditional physics classes respond to the PET-HS curriculum. Students in PET-HS classes in two different schools were given the same quizzes before and after developing ideas about positive and negative velocity as well as similar questions on the semester final exam. This method was replicated for additional topics throughout the 2016-17 school year, including Newton's second law and gravitational acceleration. Findings suggest that students from underrepresented groups show no significant difference in learning gains compared to students in majority groups. We will discuss how the PET-HS curriculum facilitates a learning environment where all students are given access to scientific principles and practices.

HA02: 3:40-3:50 p.m. Memorable Formula Recollection

Contributed – Shannon A. Schunicht, mnemonicwriting.com 3100 Barak Ln, Bryan, TX 77802-4707; animalwatch21@rocketmail.com

Initial recitation of complicated physics' formulas discourages future studies without such aspirations. A mid-air collision rendered this author unconscious for 19-days. Everything had to be relearned. Despite already having a BA from FSU, studies began a new, only without a short term memory. For this reason, the following mnemonic technique was devised for making mnemonic words from ANY applicable formula. Such a technique involves having each vowel represent a mathematical operation; i.e. a for multiplication to imply @, o to mean over, o to symbolize over, i to signify minus, u to mean plus, and e for equals. Most constants and variables are indeed consonants, e.g. c=speed of light and z=altitude. ADDITIONAL LETTERS may be inserted to enhance a letter combination's intelligibility, but need be CONSONANTS only. Examples include an acronym for The Quadratic Equation; exCePT i buiLD rabbiTS 4 caTS oN 2 HaTS. Everyone remembers Dr. Seuss. **Note how remarkable its application to Western languages is, leaving Eastern characters yet to be explored**. Regardless, its potential remains limitless as ? => 0

HA03: 3:50-4 p.m. The Doubling Interval in Unchecked Exponential Growth

Contributed – David W. Kraft, University of Bridgeport, Dana Hall, Bridgeport, CT 06604; dkraft@bridgeport.edu

Monark Trivedi, University of Bridgeport

The late Albert A. Bartlett, a past president of the AAPT, dedicated the last half of his professional life to educate both the physics community and the wider society of the implications of unchecked exponential growth.1, 2 Among the areas he addressed were human population growth and the consumption of non-renewable resources. We review and update several of his examples. Bartlett placed particular emphasis on the concept of the doubling time in an exponential process, showing, for example, that the amount of a resource consumed in a doubling interval exceeds the total consumed in all of history prior to the start of that interval. We display an applet which illustrates this concept.

1. A. A. Bartlett, Am. J. Phys. Am. J. Phys. 46, 887 (1978). 2. A. A. Bartlett, The Essential Exponential!, University of Nebraska, Lincoln, NE (2004).

HA04: 4-4:10 p.m. Students of Introductory College Physics: Who Argues More and Better?

Contributed – Jianlan Wang, Texas Tech University, 3008 18th St., Lubbock, TX 79409; jianlan.wang@ttu.edu

Zahra Hazari, Geoff Potvin, Florida International University

Students' content knowledge level is believed to be a significant factor affecting students' argumentation performance. Previous studies regarding this issue were mostly conducted through a qualitative approach. This study takes a quantitative approach to gauge the relationship between students' content knowledge and their argumentation performance. Eight argumentation items were designed and tested in a national survey study of introductory college physics students (N= 1694). The result validates five argumentation items and categories them into two constructs: perceived argumentation ability and agency. The multiple regression models indicate that students' content knowledge is not a significant predictor of either argumentation ability or agency. However, gender and physics career intentions are significant predictors of students' argumentation agency. Male students have higher argumentation agency than females. Likewise, students who intend careers in physics have higher argumentation agency than those who are less likely to intend such careers.

HA05: 4:10-4:20 p.m. The Mini-Zam: Formative Assessment for the Physics Classroom

Contributed – Robert W. Arts, University of Pikeville, P.O. Box 4352, Pikeville, KY 41502-4352; RobertArts@upike.edu

Formative assessment is a range of assessment procedures employed during the learning process in order to modify teaching and learning activities in an attempt to improve student attainment. It typically involves frequent feedback for both student and teacher that focuses on the details of content and performance. This talk will focus on a formative assessment item called the Mini-Zam used in the general physics course taken by science majors. Samples, quantitative findings, implementation, extensions to other courses, and general results will be discussed as part of the presentation.

HA06: 4:20-4:30 p.m. GeoGebra for Physics

Contributed – Lenore Horner, 7 Hills, 5400 Red Bank Rd, Cincinnati, OH 45227; Lenore.Horner@7Hills.org

GeoGebra is a versatile and accessible tool for physics teachers. It facilitates creation of everything from precise figures to interactive 3D visualizations. GeoGebra is an interactive tool that graphs functions, fits data and does statistical analysis of it, does calculus and vector math, illustrates geometry, functions in 2D, 3D or both and more. Example physics applications include re-usable/variable inclined plane and pulley diagrams, ray diagrams, forces on a rotating coil in a magnetic field, sound demonstrations, randomized practice problems with solutions. GeoGebra and visualizations created with it are free and run on computers and tablets and as a web application.

HA07: 4:30-4:40 p.m. Physics and Engineering Education – Expanding Our Agenda – Exporting Technological Literacy*

*Contributed – Carole A. Womeldorf,** STEM Engineering Educator, 168 Fleming Rd., Cincinnati, OH 45215; Carole.Womeldorf@gmail.com*

Sheila Tobias, Author: Banishing Math Anxiety (2012)

The current emphasis of physics and engineering education programs is fundamentals education, K-16 STEM education research, faculty professional development and training future academics. We propose that these departments could invaluably expand that mission by becoming sources of and home to technological literacy courses and engineering minors for non-STEM students, exporting the invaluable engineering perspective and technology fluency to a public "profoundly ignorant of technology." As an engineer, an academic, a government researcher, and a global citizen, I revisit and revive Dr. Wulf's call: "An Urgent Need for Change." As President of the National Academy of Engineering he stated: "Everyone needs an understanding of the larger innovation engine (engineering) that creates the wealth from which everyone benefits." His call for engineering schools to offer courses in technological literacy was heeded in a few key places. A review of these "engineering-enhanced liberal education" examples illustrates the rich opportunity that awaits.

*Work funded by Teagle Foundation on Engineering-Enhanced Liberal Arts Education, endorsed by the American Society of Engineering Education (ASEE). (https://www.asee.org/engineering-enhanced-liberal-education-project). **Sponsored by Dr. Lenore Horner

HA08: 4:40-4:50 p.m. Using pre-lecture Videos for the Teaching of Quantum Physics

Contributed – Patricia Bilbao Ergueta, One Physics Ellipse College Park, MD 20740; pb15@rice.edu

Andriy Nevidomskyy

Much of the development of support materials for physics education is focused primarily on introductory courses. As students become more proficient in mathematics and the class audiences more specialized, there is a tendency to default to formal derivations in the classroom in lieu of more pedagogically appropriate materials. Quantum mechanics courses suffer especially from this issue, likely due in part to the non-intuitive nature of the discipline. Using the site (www.flipitphysics.com) created by G. Gladding, M. Selen, T. Stelzer, and T. G. Ruskell, we developed a series of short video pre-lectures and accompanying quizzes meant to prime the students for each class by offering a simplified explanation of a topic to be covered in the subsequent lecture. I will present several examples of how we dealt with some of the most challenging concepts as well as the students' response to this novel approach.

Session HB: Post-deadline Abstracts II

Location: CC - Breakout 2
Sponsor: AAPT
Date: Wednesday, July 26
Time: 3:30–5 p.m.

Presider: TBA

HB01: 3:30-3:40 p.m. EXCEL-based Acoustic Analysis: Procedure and Result*

Contributed – Shinil Cho, Department of Physics, La Roche College, 9000 Babcock Blvd., Pittsbugh, PA 15101-1707; shinil.cho@laroche.edu

Dakota Leonard La Roche College

We present a systematic for investigating acoustic spectrum without using special measurement equipment. Excel-based Fourier Transform is applied to develop a hands-on spectrum analysis. Although we designed this project as part of our NSF sponsored STEM project, it also allows students of a general physics course to understand the mathematics of Fast Fourier Transform (FFT) while acquiring and observing sound samples using a PC. Several voice and piano sounds will be presented to demonstrate the analysis steps. We also discuss how to overcome the 4096-data point limitation Excel-based FFT and other issues we observed.

*Research supported in part by NSF-1356196

HB02: 3:40-3:50 p.m. Using Medical Imaging to Engage Health Science Students in Physics

Contributed – Stacy McCormack, University of Indianapolis, 1400 Hanna Avenue, Indianapolis, IN 46227; mccormacks@uindy.edu

One of the biggest complaints we hear from students in our introductory physics course sequence is that they see no relevance between our required physics courses and their health science majors. This spring I partnered with local radiologists to design a project whereby students in my introductory algebra-based electricity/magnetism course researched medical imaging techniques: Ultrasound, X-ray, MRI, CT, and PET. The project required a research paper and informational poster to be created by the students, and brought a classroom visit from local radiologists as well as a field trip and tour of the hospital imaging departments. I will give tips for how to begin such a partnership at your own location, show examples of student projects and feedback, as well as share lessons learned and how the project will be changed going forward.

HB03: 3:50-4 p.m. Using Direct Measurement Videos to Teach Model-Making and Model-Breaking Skills

Contributed – Matthew Ted Vonk, University of Wisconsin River Falls, 410 S 3rd St., River Falls, WI 54022; matthew.vonk@uwrf.edu

Peter Bohacek, Pivot Interactives SBC

Many instructors struggle to find efficient ways for their students to discover quantitative relationships. This talk will explore a novel new platform, Pivot Interactives, that lets students do just that. The platform allows users to design and perform experiments by controlling certain critical parameters within arrays of high-resolution videos. In addition, the talk will illustrate how the same platform can be used to help students investigate those instances where the simple models we give them start to fail.

HB04: 4-4:10 p.m. Christian Fundamentalists in the Physics Classroom

Contributed – Sean M. Cordry, Walters State Community College, 500 Davy Crocket Pkwy., Morristown, TN 37813; smcordry@ws.edu

An NSF survey revealed that 24 percent of Americans believe the Sun goes around Earth. That percentage may increase due to the rise of the religious home-schooling movement, in which between 49 to 85 percent consider themselves to be "born again" Christians. Curricula for home-schoolers is dominated by a fundamentalist slant, with statements of faith espousing belief in special six-day creation, websites claiming "The ONLY Common Core we ascribe to is God's Word," and curricula series titles such as "Sonlight." As the number of religiously conservative students increases in our classrooms, it is important to know how to address them and their needs. In this talk, I will share experiences and practical insights to help navigate difficult waters. Topics discussed will include characteristics of the fundamentalist Science vs. Scripture paradigm, understanding the background of these students, how Creationism undermines critical thinking, and pitfalls to avoid.

HB05: 4:10-4:20 p.m. Investigative Lab Activities for Large Enrollment Studio Physics Classes and Argument-driven Reports

Contributed – Kathleen T. Foote, University of Auckland, 38 Princes Street, Level 6, Auckland, Auckland 1010 New Zealand k.foote@auckland.ac.nz

To prepare students for success in today's fast-paced, modern world, departments are increasingly being asked to explicitly incorporate real world skills into their courses such as teamwork, using technology, reasoning from evidence, communicating effectively and more. Motivated by a desire to cover more than just content in their physics courses, University of Auckland recently adopted the Studio Physics format, which integrates lab, lecture and tutorial in a highly interactive reformed classroom. Since now a hundred students undertake lab investigations concurrently, we designed experiments that utilized the versatile Lablet app (for data capture and analysis on tablets), economical and space efficient equipment. Instead of handing students a detailed lab manual, students embark on a more open-ended challenge such as "determine the spring constant of a ballistic launcher." The students have more autonomy in designing an experiment, consciously move through a more scientific process, then they summarize their experiment in a one page, argument-based report. Students undergo a peer review process before final submission so students learn how to evaluate information in science and develop their ability to read and critique an argumentative text, while emulating an important part of science. This talk will describe the development of experiments and accompanying materials, including the rubric, which outlines the expectations for students and facilitates fair grading for instructors. It will include preliminary feedback and data from the first semester of implementation.

HB06: 4:20-4:30 p.m. Hand-Driven Systems for Demonstrating Resonance

Contributed – D. Blane Baker, William Jewell College, 500 College Hill, Liberty, MO 64068-1896; bakerb@william.jewell.edu

Dylan Welsch, William Jewell College

Resonance is one of the most prevalent topics in physics and has implications for research in fields ranging from nuclear theory to astronomy. In order to help students visualize what happens at resonance in mechanical systems, we have developed several classroom demonstrations. These particular demonstrations use common items such as hacksaw blades, ropes, and springs. Moreover, each system is chosen so that it can be driven into resonance by moving it or shaking it at a few Hz. Several systems will be presented along with how each can be related to other areas of physics or to questions of practical interest. For example, the presence of a node of vibration near the free end of a thin board at resonance can be related to the "sweet spot" of an implement such as a baseball bat.

HB07: 4:30-4:40 p.m. Impact of High-Engagement Activities on Online Introductory Physics Classes

Contributed – Anthony Smith, Central Washington University, 400 E. University Way., MS 7422, Ellensburg, WA 98926-7501; anthonys@cwu.edu

The increasing demand for online Physics classes presents the challenge of transferring student engagement from a physical to a virtual classroom. Online students often feel isolated from the instructor, from each other, and even from the material, with students from high-context environments feeling especially disconnected. High-context activities, such as posting in a class introduction thread, attending online office hours, and working on laboratory activities in groups, were incorporated into an online Introductory Physics series. Students showed an improvement in scores on a standardized concept inventory, and positive feedback on a post-class survey. This project was done as part of the ESCALA Education program.

HB08: 4:40-4:50 p.m. The Use of Peer Instruction to Revisit Leibniz-Descartes Quarrel

Contributed – Marlon V. Soares, Pontifical University Catholic of Parana, Av. Visconde de Guarapuava, 2764 work1603 Curitiba, PR 80010100 Brasil; marlon.soares.fisica@gmail.com

The active teaching-learning methodologies have been increasingly used in Brazilian engineering undergraduate courses. In this paper, we propose a method to investigate the previous knowledges that given engineering students have about Newton's 2nd Law and analyze their skills toward the use of this law to solve qualitative problems. Despite the fact of Newton's Laws are mandatory subject in High School, a lot of undergraduate students are not able to properly apply it to solve conceptual problems. They can identify the equation that expresses the Newton's 2nd Law, but they do not have a fully understanding of its meaning. We have identified that the misunderstanding lies to the difference between the meaning of linear momentum and the meaning of force, which we can point out to be the same misconception that occurred in the history of science episode involving Descartes and Leibniz, back in XVIII Century.

HB09: 4:50-5 p.m. Smartphone Experiments with Integrated Data Analysis Using "Phyphox"

Contributed Sebastian Staacks, RWTH Aachen University, 2nd Institute of Physics A, Templergraben 55, Aachen, 52062 Germany; kuhlen@physik.rwth-aachen.de

Simon Hütz, Heidrun Heinke, Christoph Stampfer, RWTH Aachen University

Smartphones are a fascinating tool for physics experiments as they provide a wide range of sensors allowing to do data acquisition without additional hardware. While sometimes the analysis of this data represents an important aspect in science classes, many smartphone experiments suffer from a lack of focus as students spend a disproportionate amount of time working with external analysis software. Moreover, the acquired data appears disconnected from the actual experiment as the phone is either inaccessible or only raw data can be examined during measurement. In this talk I will present the free app "phyphox" (Android and iOS, see http://phyphox.org) which offers live data analysis for smartphone experiments and a simple means to remote control it from any device. I will contrast how experiments can be carried out using pure data acquisition or full data analysis and how each approach can help you emphasize different aspects of your lesson.

Session HC: Post-deadline Abstracts III

Location: CC - Breakout 3
Sponsor: AAPT
Date: Wednesday, July 26
Time: 3:30–5 p.m.

Presider: TBA

HC01: 3:30-3:40 p.m. Rebuilding a Pre-Service Elementary Teacher Integrated Science Course (Physics/Chemistry) at Fresno State.

Contributed – Roger A. Key, Fresno State Physics Department, 2345 E San Ramon Ave, MS-MH-37, Fresno, CA 93740; rogerk@csufresno.edu

Anthony Hinde, Donnie Golden, Dermot Donnelly, Fresno State Chemistry Department

Don Williams, Fresno State Physics Department

Physical Science is often taught and assessed in a disciplinary and fragmented way, with little connection made between chemical and physical explanations of scientific phenomena. As such, many students lack coherent and holistic explanations of scientific phenomena, phenomena that are a key component of the Next Generation Science Standards (NGSS) for K-8 students. This presentation will discuss the redesign of a pre-service K-8 teacher physical science course to better align disciplinary and integrated explanations of scientific phenomena. Chemistry, Physics, and Physical Science (Integrated) phenomena based items were developed and scored using knowledge integration rubrics to score students' explanations pre/post instruction. Example items and rubrics relevant to the items will be presented in this session alongside redesigned laboratory curriculum and findings relevant to the pre-service elementary teachers' conceptual development. Finally, important implications for Physical Science instruction will be highlighted.

HC02: 3:40-3:50 p.m. A Laboratory to Teach Laser and Atomic Physics

Contributed – Joseph E. Wiest, West Virginia Wesleyan College, 59 College Ave., Buckhannon, WV 26201; wiest@wvwc.edu

For the past 25 years I have been creating a laboratory to use the laser to teach hands-on techniques of studying the atom, and including the nucleus in interpretation. Experiments have been developed around the following lasers: solid-state tunable diode lasers, HeNe lasers, nitrogen laser, carbon dioxide laser, and ruby laser. The lasers employed have been a combination of commercial and shop-built instruments. Studies with the lasers emphasize their history and development, the doublets and hyperfine structure of Cs, K, and Rb, the acousto-optic effect, bond strength of the iodine molecule, the nitrogen-pumped dye laser, Raman Effect, frequency doubling, and the stable isotopes of Kr. Building the tunable diode laser and detectors, the use of the wavemeter, CCD camera, and miniature digital spectrometer will be discussed.

HC03: 3:50-4 p.m. Developing Newton's Universal Law of Gravitation with Real Astronomical Data

Contributed – Lucas G. Walker, Weston High School 127 Blueridge Rd., Fairfield, CT 06825-3735; lucas.walker.7@gmail.com

Adoption of NGSS will require teachers to come up with authentic ways for students to develop fundamental laws of nature through observation and analysis. A rule like the Law of Gravity has been traditionally accepted on faith, because Newton's own analysis is too arcane and complex for them to productively follow. But students can actually easily develop the 1/r-squared mathematical relationship on their own by analyzing a new, freely-available trove of data – the exoplanet orbital database! I have developed an instructional sequence that begins with the curious observation that the ISS is accelerating at only 9.1 m/s per second, and eventually guides students to design the experiment investigating how acceleration changes with orbital radius. Finally, they discover the appropriate mathematical model on their own by analyzing real exoplanet data using free graphing calculator software available online, in support of the NGSS expectation that students "develop AND use mathematical models."

HC04: 4-4:10 p.m. A Theoretical that Gives a Unified Explanation of Electrostatic Forces and the Universal Gravitation

Contributed – Rolex Rao, Future Start / Candle Light Educational Fund 1570 Tenaka Place, #1 Sunnyvale, CA 94087; futurestartclass@gmail.com

A theoretical model that provides a common ground on which the Coulomb's law and Newton's law of universal gravitation can be unified. This model also explains what the attractive mass is and why it's directly proportional to inertial mass. Newton's law of universal gravitation and Coulomb's law were discovered separately in 1687 and 1784. These two laws resemble each other in many ways, but people didn't explain why these two laws both are inverse-square and why inertial mass are identical to attractive mass. Here we provide a reasoning briefly and logically why an asymmetry could exist in our universe and we showed mathematically how this asymmetry will lead to an inverse-square gravitational force in addition to Coulomb's forces. The theory fits with currently used theory at an expense of losing the simplicity of electric field at the first look. A mathematical tool is developed to handle the calculation of field and forces under the hypothetical asymmetry, with the tool we can easily show that both Coulomb's force and gravitational force can be put into the same theoretical frame work. Moreover, in this hypothetical model we provided a long-awaited answer for what is attractive mass and why it's directly proportional to inertial mass. If this model stands, we hope it's the missing piece of the big picture for the union of fundamental forces and theories to describe them, including quantum mechanics and relativity.

HC05: 4:10-4:20 p.m. A Model Explains Coulomb's Forces, Charges, and Inverse-Square Law

Contributed Rolex Rao Future Start / Candle Light Educational Fund 1570 Tenaka Place, #1 Sunnyvale, CA 94087 futurestartclass@gmail.com

A theoretical model, which naturally reproduces the attractive and repulsive forces between charges and the mathematical formula of Coulomb's law, gives an explanation of what charges are, their structure and functions, and why Coulomb's law is inverse-square. Coulomb's law, since it was discovered in 1784, has many interesting features that were not explained based on more basic understanding. To explain why the Coulomb's law is inverse-square, we developed a theoretical model for the structure and function of positive and negative charges. Based on this model, we can reproduce the mathematical formula of Coulomb's force using a different approach. This hypothetical model also gives some lights on how the universe is running its energy.

HC06: 4:20-4:30 p.m. 3D-Printed Kelvin Current Balance

Contributed – Thomas E. Wilson, Marshall University, Department of Physics, Huntington, WV 25755-0001; wilsont@marshall.edu

We have developed a modern, compact and low-cost 3-D printed version of the Kelvin current balance that is well-suited for use in any instructional physics laboratory. We use two current circles, each wound with a large number of turns (typically 90, with 30 AWG enameled-magnet wire) and positioned coaxially and lying in parallel planes. One such current circle rests upon a miniature low-cost digital scale which measures the force of repulsion (or attraction). The current balance is completed with the other current circle positioned above the first on a supporting stand. A precise spacing is achieved using low-cost 3-D printing technology. Two separations (9.0 and 16.0 mm) have been used thus far to measure the force (chosen to be either repulsive or attractive) as a function of modest currents (one ampere or less is sufficient for accurate results). The measured forces are found to be in excellent agreement (within 3%) with a classical electromagnetism analytical expression. The particular digital scale we have used thus far, is the low-cost AWS Gemini-20 with a capacity of 20 gm in 0.001 gm increments, although the 3D-printed rings and stand can can be easily adapted for other use with other digital miniature scales. In addition, the mutual inductance between the circles can also be conveniently measured using a signal generator and a two channel oscilloscope, and compared to theory. Excellent agreement (within 1.5%) is also found between the measured mutual inductance and the theory, for the spacing of 6.2 mm.

HC07: 4:30-4:40 p.m. It's Not Harvard. Does It Still Work?

Contributed – Paul J. Walter, St. Edward's University, 3001 S Congress Ave., Austin, TX 78704; pauljw@stedwards.edu

This past year we adopted and implemented the team-based and project-based model for introductory physics that was developed by Eric Mazur's group at Harvard University. We discuss some of the benefits and challenges of Harvard's AP-50 course design. We also discuss potential modifications, such as including computation into the course.

HC08: 4:40-4:50 p.m. Impact of Prelab Videos on Introductory Life Sciences Physics Laboratories.

Contributed – Matt Steffler, University of Guelph, 50 Stone Rd. E., Guelph, ON N1G 2W1 Canada; stefflem@uoguelph.ca

Duncan Brain, Braeden Skene, Martin Williams, University of Guelph

We discuss our implementation of targeted prelab videos designed for laboratory exercises in a large enrollment (900 student) introductory physics for the life sciences course. Our goal was to create preparatory videos that helped students have a better appreciation of the role of labs, strengthen conceptual understanding, and reduce time on task. Students were asked to take part in a survey about their experiences with the videos and the labs. Such factors as time to complete labs, impressions on lab manageability and insight gained, and overall comments were gathered and analyzed. We found that 45 - 55% of students completed the prelab videos on a regular basis, which is much lower than anticipated. When time on task for individual labs was compared, it was found to have increased rather than decreased for the majority of the labs. We will discuss in the talk the implications of these results.

HC09: 4:50-5 p.m. Implementation of Learning Module Methodologies in General Physics Courses

Contributed – John Barr, Lindenwood University, 209 South Kingshighway, St. Charles, MO 63301; jbarr@lindenwood.edu

Sajalendu Dey, Lindenwood University

Student outcomes in general physics courses reflect a lack of conceptual understanding.[1] A learning module-based course design is proposed to address this lack. "Lecture" sessions will be broken into learning modules that utilize a minimum of traditional presentation followed by peer involved concept questions[2] and group problem solving. Each class session will contain two to three learning modules. Students will be required to prepare for each lecture ahead of time by doing appropriate reading and problem solving. Learning module structures that cover the essential elements of a general physics-I class will be presented.

(1) Lorin W. Anderson, Lauren A Sosniak (Editors), Bloom's Taxonomy: A Forty-Year Retrospective (University of Chicago Press, 1994). (2) E. Mazur, Peer Instruction: A User's Manual (Prentice-Hall, Upper Saddle River, NJ, 1998).

PST3: Post-Deadline Posters

Location: CC - Madison Lobby
Sponsor: AAPT
Date: Wednesday, July 26
Time: 3:30–5 p.m.

Poster presenters are asked to mount their posters before 8 a.m. The posters should be taken down at 5 p.m. Persons with odd-numbered posters will present their posters from 3:30 to 4:15 p.m.; those with even-numbered posters will present from 4:15 to 5 p.m..

PST3A01: 3:30-4:15 p.m. Development of an Interactive Tutorial on Quantum Key Distribution*

Poster – Seth T. DeVore, West Virginia University, 135 Willey St., Morgantown, WV 26506; stdevore@mail.wvu.edu

Chandralekha Singh, University of Pittsburgh

We describe the development of a Quantum Interactive Learning Tutorial (QuILT) on quantum key distribution, a context that involves a practical application of quantum mechanics. The QuILT helps upper-level undergraduate students learn quantum mechanics using a simple two-state system and was developed based upon the findings of cognitive research and physics education research. One protocol used in the QuILT involves generating a random shared key over a public channel for encrypting and decrypting information using single photons with non-orthogonal polarization states, and another protocol makes use of two entangled spin-½ particles. The QuILT uses a guided approach and focuses on helping students build links between the formalism and conceptual aspects of quantum physics without compromising the technical content. We also discuss findings from a preliminary in-class evaluation.

*Supported by the NSF.

PST3A02: 4:15-5 p.m. The Structure and Method of Planning in Group Work

Poster – Alyssa C. Waterson, Michigan State University, 2438 Burcham Drive, East Lansing, MI 48823; waterso8@msu.edu

Paul W. Irving, Michigan State University

Marcos D. Caballero, Michigan State University

This research is dedicated to identifying and properly structuring the way that groups in group-based learning can effectively plan through complex physics problems. With the growing field of group based learning environments, instructors of these classes are beginning to give formative feedback to the students, allowing them to develop physics based practices. One of the most difficult areas of group work is the planning stage – students not only need to know what the problem is asking for: they also need to make connections between the goal and the given information, they need to make representations that fit the problem's description, and they need to know how to sanction their time properly. These are few among many aspects that facilitators have to acknowledge and adapt to addressing when helping their students develop. The research presented here explores the structure of planning and its manifestation in class.

PST3A03: 3:30-4:15 p.m. Beyond Pure Data Acquisition: Smartphone Experiments With "Phyphox"

Poster – Sebastian Staacks, RWTH Aachen University 2nd Institute of Physics A, Templergraben 55 Aachen, 52062 Germany; kuhlen@physik.rwth-aachen.de

Simon Hütz, Heidrun Heinke, Christoph Stampfer, RWTH Aachen Univ.

The free app "phyphox" (Android and iOS, see http://phyphox.org) is a set of tools using the sensors in common smartphones for physics experiments. Instead of just offering simple data acquisition, this app can do integrated data analysis and allows to view the results on any second device (laptop PC, tablet, a second smartphone etc.) during the measurement - even when the phone itself is not accessible. This way, students can see the outcome of an experiment and the influence of their actions live while conducting the experiment. Additionally, any experiment-specific analysis can be customized and changed through an open file format to adjust the app to your needs and the skills of your students. The poster will be presented by the developer of the app who is looking forward to give technical advice, discuss new experiment ideas and exchange actual teaching experiences.

PST3A04: 4:15-5 p.m. Demonstration of Heart Model for Ultrasound Imaging

Poster – Karen A. Williams, East Central University, 1100 E. 14th St., Ada, OK 74820; kwillims@mac.com

Brian Scott, East Central University (former)

With my input about our present equipment, a former student of mine designed a better, far cheaper, and more durable yet simple heart model for ultrasound imaging than was sold to us. I will demonstrate how the heart model functions and share the parts list and laboratory information to those interested. Local high school teachers intend to have their students use Vernier motion detectors to obtain data in the absence of an echoscope.

PST3A05: 3:30-4:15 p.m. Discussion Method and Educational Effect in Physics Mechanics Lectures

Poster – Taku Nakamura, Gifu University, Japan, 1-1, Yanagido, Gifu, Gifu City, 501-1193 Japan; nakamura@gifu-u.ac.jp

Kazuma Aoki, Gifu University, Japan

In this research, we practiced with three different teaching methods in the class of mechanics of university first grader, and compared the effect. Practice 1 is lectures based on group work and inquiry activities, practice 2 is lectures based on workshop and peer instruction, practice 3 is lectures based on teacher's demonstration experiments using experimental animation. In each practice, the method of discussion is greatly different. In practice 1, learners freely discuss how to explore activities. In practice 2, learners discuss the concept of each theme for 2 minutes. In practice 3, the learners first discuss the concept of the theme in pairs, then discuss in a group of four people, and finally discuss the class as a whole. The effect of each lectures were evaluated using the normalized gain of Force Concept Inventory. Practice 3 which repeats discussion on the same theme has the best result.

PST3A07: 3:30-4:15 p.m. Postural Control: A Study of One-Legged Stance

Poster – Matthew R. Semak, Department of Physics and Astronomy, University of Northern Colorado, Campus Box 127, 0232G Ross Hall, Greeley, CO 80639; matthew.semak@unco.edu

Taylor McMillan, Jeremiah Schwartz, Department of Physics and Astronomy, University of Northern Colorado

Gary Heise, School of Sport and Exercise Science, University of Northern Colorado

We investigate certain characteristics of human unipedal balance control. Data were collected via a force plate for individuals attempting to maintain upright posture using their dominant and non-dominant legs (with eyes open). The force and jerk concerning the center-of-pressure for each foot has been examined using, among other methods, power spectral and detrended fluctuation analyses. For the sake of space, this poster will focus on results for the jerk associated with the dynamics of the subjects' dominant legs. Both the lateral and longitudinal components of the jerk display (what may be) oscillatory behavior on long time scales. On short time scales, the longitudinal component of the jerk shows persistent correlations which can be modeled by fractional Gaussian noise, while the lateral component appears to lack strong temporal correlations. Moreover, we attempt to distinguish behavior associated with the dominant leg's dynamics from that of the non-dominant using sample entropy estimates.

PST3A09: 3:30-4:15 p.m. Correlation Between First Exam Scores and Ffinal Grades

Poster – Sandra L. Doty, Ohio University Lancaster, 1571 Granville Pike, Lancaster, OH 43130-1097; dotys@ohio.edu

In a study by Jensen and Barron published in the Journal of College Teaching, a significant correlation was found between first exam scores and the final course grade for introductory biology courses. This study explores the relationship between student performance on the first exam, final exam, and final course grade in the introductory algebra- and calculus-based physics course at regional campus and liberal arts institutions.

PST3A10: 4:15-5 p.m. How Might We Help Our Students Become Leaders?*

Poster – Vincent H. Kuo, Colorado School of Mines, 1232 West Campus Road, Golden, CO 80401; hkuo@mines.edu

Pat Kohl, Mark Lusk, Leslie Light, Yosef Allam, Colorado School of Mines

This presentation will describe the current status of our recent attempts to reform pedagogy and content in several courses at Mines, both horizontally in the common core as well as vertically in the physics major. Starting from motivation, this presentation will include our philosophy, methods, and implementations in the various courses to create a more coherent effort to facilitate leadership and group dynamics development in our students. Courses in the common core include Introductory Physics I & II, Calculus III, Differential Equations, and EPICS I (Engineering Practices - Interdisciplinary Core Sequence). Physics major courses include Analog Electronics, Digital Circuits, Classical Mechanics, Intermediate E&M, and Advanced E&M. The presentation will also discuss our plans on the longitudinal tracking of our students.

*This work is funded by the Office of Naval Research (award #: N00014-15-1-2435).

PST3A11: 3:30-4:15 p.m. Modeling Bacterial Swimming of Helical Flagella

Poster – Philip Lockett, Centre College, Box 56, Fairfield, KY 40020; lockett@centre.edu

Grant Giesbrecht, Bruce Rodenborn, Centre College

Our experiment models the locomotion of bacteria using a macroscopic robotic swimmer. Our swimmer has a motor that drives a helical flagellum similar in shape to those present in many prokaryotic organisms. In order for our swimmer to behave like a bacterium, a dimensionless parameter, the Reynolds number, must be kept the same. Since bacteria are much smaller than our robot, we compensate by using a highly viscous fluid. A bacterium swimming in water is like our robot swimming in corn syrup! The presence of nearby boundaries has significant effects on the swimming of microorganisms. We have developed a system to precisely control the distance from the flagellum to the wall and have made measurements of forces and torques near the boundary.

PST3A12: 4:15-5 p.m. Students' Explanations of Physics Problem Scenarios After Performing an inquiry-based Experiment in Two-Dimensional Motion

Poster – Edgar D. Corpuz, University of Texas-Rio Grande Valley, 1201 W. University Dr., Edinburg, TX 78539; edgar.corpuz@utrgv.edu

Ma. Aileen A. Corpuz, University of Texas-Rio Grande Valley

Brenda Ramirez, McAllen High School

This research investigates students' explanations of physical phenomena presented as problem scenarios after performing discovery-based physics experiments. In this presentation, we will document the categories of explanations that students use in making sense of situations requiring them to apply concepts of two-dimensional motion. Our preliminary results show that most students do not readily apply the concept/physical principle learned in the experiment in making sense of problem scenarios designed as applications of the said experiment.

PST3A13: 3:30-4:15 p.m. Systematic Development of Skills in Open-Ended Labs

Poster –Inkeri Kontro, University of Helsinki, P.O.B. 64, Helsinki, 00014 Finland; inkeri.kontro@helsinki.fi

The intermediate laboratory courses at the University of Helsinki were reformed to collaborative, open-ended problem solving labs. The result was a self-contained laboratory course that consists of a weekly instruction workshop, calculation exercises that support the laboratory exercises, and laboratory assignments. The biweekly changing laboratory assignments give students a chance to change their strategy or redo measurements after preliminary data-analysis. The focus is on skills, e.g. building or choosing measurement devices for a particular problem, data-analysis skills and choosing research questions. Each laboratory assignment is focused on two learning goals. Skills are built up systematically. This requires multiples of the same equipment to be available, which in turn means the equipment must be affordable. In this poster we present our laboratory works and the students' attainment to learning goals.

PST3A14: 4:15-5 p.m. Network Analysis of IMPRESS Summer Program

Poster – Katarzyna Pomian, DePaul University, 1536 Courtland Dr., Arlington Heights, IL 60004; kasia.pomian@yahoo.com

We are exploring the impact of collaborations between students, both in small groups and in the larger class setting. We are also interested in understanding how the interactions change over the course of a two-week summer program. The context for our study is the summer IMPRESS (Integrating Metacognitive Practice and Research to Ensure Student Success) program at RIT (Rochester Institute of Technology). The IMPRESS program works with first generation students and deaf and hard-of-hearing students in helping them to develop metacognitive and self-assessment tools. These are students that are incoming freshman to the STEM fields at RIT. We apply social network analysis (SNA) to collected video data of the entire two-week period. This method of analysis gives us a way to describe the IMPRESS students' collaboration quantitatively and visually to answer our research questions. This is an approach for studying individual student's integration into a group as well as dynamics of the group. We are also looking at how the on-topic and off-topic conversations may contribute to the larger networking of the students involved in the program.

PST3A15: 3:30-4:15 p.m. Experiences from Implementing IPLS Lab Activities

Poster – Jeremy D. Hohertz, Elon University, 5671 Whippoorwill Dr., Pfafftown, NC 27040; jhohertz@elon.edu

Shon Gilliam, Elon University

Elon University transitioned the algebra-based introductory physics laboratory activities to an IPLS curriculum during the 2015-2016 academic year. We present some logistical details of the implementation, student and instructor perceptions of the new curriculum, changes made for the 2016-2017 academic year, and planned changes for the 2017-2018 academic year.

PST3A16: 4:15-5 p.m. Examination of the Level of Inquiry in Introductory Physics Laboratories

Poster – Zeynep Topdemir, Georgia State University, One Park Place, Atlanta, GA 30302; ztopdemir1@student.gsu.edu

Ebru Oncul, Brian D. Thoms, Georgia State University

Inquiry-based experiments are common in K-12 education, but unfortunately, there are less common in undergraduate education. Also, it is not clear in the literature what kind of activities should be counted as inquiry-based. The aim of this study is to develop a rubric to characterize and specify the level of inquiry in introductory undergraduate physics labs. We have used this rubric to determine the level of inquiry in introductory physics laboratories at Georgia State University. Also, this rubric has been used to characterize the level of inquiry of some published research-based introductory physics labs. Preliminary results will be presented. We will also show how traditional labs can be converted into inquiry-based labs.

PST3A18: 4:15-5 p.m. Approaches to Assisting Elementary Education Majors with Lunar Concepts

Poster – Matthew P. Perkins Coppola, Indiana University Purdue University Fort Wayne, Department of Educational Studies, Fort Wayne, IN 46805; perkinsm@ipfw.edu

In order to prepare the next generation of elementary school teachers to teach astronomy concepts, specific activities are included in their science methods course that use modeling practices to address common misconceptions and alternative conceptions. Accessible materials and electronic simulations are used in sequence to build conceptual models of how the moon progresses through its phases and why lunar eclipses are not a monthly event. This poster documents my efforts toward this task.

PST3A20: 4:15-5 p.m. Electrolysis of Salt Water and Batteries

Poster – Tracey DeLaney, West Virginia Wesleyan College, 59 College Ave., Buckhannon, WV 26201; delaney_t@wvwc.edu

This is a lab exercise used in our Physical Science for Teachers class. Our goal is to provide the elementary education students with ideas that they can use in their own classrooms some day. The materials are cheap and easy to make or acquire. The first experiment uses pencils, salt water, and a 9-volt battery to drive electrolysis. The graphite in the pencils serves as the electrodes. The second experiment uses copper, zinc, and aluminum electrodes to make batteries with Coke (or lemons) as the electrolyte. The electrodes for the battery can be nails or flashing cut into strips. The students use multimeters to take voltage and amperage readings in each experiment. For the battery experiment, the students

PST3A23: 3:30-4:15 p.m. Grading and Motivation: Case Study of an Ongoing Struggle

Poster – Ralph Tadday, Linn-Benton Community College, 6500 Pacific Blvd., Albany, OR 97321; taddayr@linnbenton.edu

Do you struggle finding enough time to grade your students' work and give meaningful feedback? Are you the idealist that believes that your grading effort matters to students learning, and your feedback is valued and actually makes a difference? I do, and therefore I found/find myself spending a weeks worth of work every week grading my students work. Three years ago I started changing my grading system motivated by discussion with colleagues at the community college and Universities, and influenced by reading about "Specifications Grading" (Linda B. Nilson, Stylus 2015). As expected my grading time decreased, the interaction with students intensified. Many of the interactions are physics related, a significant number of interactions were purely grade related. Unexpectedly also the interaction with colleagues and administrators increased. A critical review is presented.

PST3A25: 3:30-4:15 p.m. Standards-based Grading: Assessing What Students Can Do

Poster – Katrina E. Black, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931; keblack@mtu.edu

Standards-based grading systems assign grades based on student mastery of course objectives rather than a percentage of points earned on each particular assessment. In spring 2017, I implemented standards-based grading in an algebra-based introductory physics course for technology majors. I discuss how I chose my standards and grading scale, how standards-based grading affected the culture of the course, and changes in final grade distribution and FMCE gains compared to previous semesters.

PST3A26: 4:15-5 p.m. The Solar Eclipse and the Detection of Atmospheric Muons

Poster – Matthew R. Semak, University of Northern Colorado, 0232G Ross Hall, Campus Box 127, Greeley, CO 80639; dr.matthew.semak@gmail.com

Josh Fender, John Ringler, Justin Morse, University of Northern Colorado

For this project, we have constructed a device for the detection of cosmic ray muons as a function of altitude. The detector is part of a self-contained autonomous payload that is carried up to altitude aboard a weather balloon. The payload contains a plastic scintillator coupled with a silicon photomultiplier and two Geiger counters. All three are connected to a coincidence circuit, making up the muon detection system. This system, along with various other sensors including an internal temperature sensor and altimeter, are controlled by an onboard Arduino Mega microcontroller. A launch in July 2017 will serve as a test flight for the payload and baseline data will be collected. These data will be compared to those collected during a similar flight at the time of the solar eclipse in August 2017 to determine if there is a measurable difference between the data sets.

PST3A27: 3:30-4:15 p.m. Uncertainty: Student Attitudes and Proficiencies

Poster – Michelle L. Milne, St. Mary's College of Maryland, 47645 College Drive, St. Mary's City, MD 20686-3001; mlmilne@smcm.edu

Students in a calculus-based, introductory physics class primarily taken by non-physics majors were sorted into two groups. The groups were taught uncertainty using two different presentation methods throughout the semester: One method emphasized the uncertainty (the lack of knowledge) about the experimental measurements or results while the other emphasized the certainty of the measurement or results. The students' lab reports were rated for proficiency with uncertainty concepts throughout the semester and the students' attitudes towards uncertainty concepts were collected using a Likert attitude survey taken at several points during the semester and once at the end of the next semester. No significant difference was found in either competency or attitudes between the two groups. Both groups improved in proficiency over the course of the semester.

PST3A28: 4:15-5 p.m. A Simple Laser Microphone

Poster – Jorge A. Salas, Department of Physics and Astronomy, Stevenson Science Center 6639A, Nashville, TN 37325; jorge.a.salas@vanderbilt.edu

A simple microphone can be built using a laser, a phototransistor, earphones and some additional electronics. This microphone has been used by the author as a fun and interactive demonstration to introduce students into topics such as lasers, optoelectronic sensors, amplification, filtering, mechanical oscillations, resonance, feedback and others. The device is inexpensive and easy to build, and yet has good sensitivity. The demonstration can be tailored to broad audiences, from children up to college students.

PST3A29: 3:30-4:15 p.m. Computer Visualization of Image Fields in Multi-lens Systems

Poster – James G. Kelly, Centre College, 600 W. Walnut St., Danville, KY 40422; james.kelly@centre.edu

While traditional lens diagrams effectively illustrate how a single object plane is focused in a single image plane, they can leave gaps in understanding when relied upon as the sole method of illustration for optical instruments. I will display a method for computer visualization of image structures in single and multi-lens systems that provides intuition about optical systems in ways that lens diagrams do not. Entire fields of objects and images are simultaneously visualized, directly displaying the necessary distortion of objects with both lateral and axial extents. It can display the often misunderstood effect of lens apertures of any eye position on the image field, and provides a more robust understanding of optical instrument design principles. The method is appropriate for a first encounter with optics as a follow-on to lens diagram constructions.

PST3A30: 4:15-5 p.m. TAPIR (Teaching Activities for Physics Inclusion Resources): Enhancing Diversity in Introductory Physics

Poster – Kobi K. Bhattacharyya, Colorado College, Physics Department, 14 E. Cache la Poudre, Colorado Springs, CO 80903-3294; bwhitten@ColoradoCollege.edu

Brooks Thomas, Lafayette College

Barbara L Whitten, Colorado College

Even among STEM disciplines, physics stands out as unusually white- and male-dominated. AIP reports that only 14% of physics faculty are women, and 6% are underrepresented minorities. Rachel Ivie of AIP has studied the pipeline for women in physics, and has identified the transition from high school to college as the most important "leak point" for women. We are approaching this problem by addressing inclusiveness in the calculus-based introductory physics course, the gateway to the undergraduate physics major. While most physics books have a plethora of problems at the end of each chapter, they are focused on contexts like sports and the military, which are not of particular interest to women or students of color, and send the message that physics is not for them. Many young faculty who are interested in diversity would like to present a broader variety of contexts. But, pressed for time, they too often fall back on already prepared topics. We are preparing a database of materials (coloradocollege.website/tapir) that illustrate the concepts of introductory physics, but in different contexts that we intend will interest a broader range of students. These might include problems, in-class activities, test problems, paper and discussion topics. We intend these materials for use in the calculus-based physics class, but they will be adaptable to algebra-based and high school classes as well. By making these available to faculty at Colorado College and elsewhere, we hope to encourage women and students of color to major in physics, and eventually increase the diversity of the physics community.

Wednesday

Index of Participants

Abbott, David, W39
Adams, Wendy K, EC02, BL03, FM02, PST2A05, W30
Adhikari, Ramesh, FK08
Agrest, Mikhail M, BF06
Agrimson, Erick, BF05, W27, BF07
Airey, John, EF12, FK03, PST1E56
Alcântara, Miriã Alves, PST1A10
Alexakos, Konstantinos, CH06, CH08
Ali, Sidra F., BK04
Alicea-Munoz, Emily, BI08
Allain, Rhett, EE01
Allam, Yosef, PST3A10
Allen, Patricia E., PST2B22, PST2B24
Allie, Saalih, EK11, PST2D49
Allred, David D., DI06
Almeida, Heloisa B, PST1A01
Alshahrani, Mohammad S., FB06
Alvarado, Carolina, CJ08, CH07
Alzen, Jessica, DA03, EB05
Ambrose, Bradley S, BF09
Amezcua, Fidel, PST1A02, PST1E05
Amiri, Farhang, CI05
Amos, Nathaniel, EK03, AK01
Anderson, Charles, FH05, PST1B02
Anderson, Colby, GI05
Andreas, Müller, AA01
Ansell, Katherine, EF19, EJ04
Aoki, Kazuma, PST3A05
Aravind, Vasudeva R., GI08
Archibeque, Benjamin, FH03, CH05
Arpin, Paul C, CD03
Arts, Robert W., HA05
Aryal, Bijaya, DE02
Ashman, Seth, EF04, GI05
Atwood, Charles H., EB02
Audunsson, Haraldur, PST2B15
Augensen, Isabelle, PST2D01
Aumen, Laura, PST2C02
Ayers, Drew, FI01
Badeau, Ryan, AK05, PST1E52, CK02
Baer, Robert, BF01
Bailey, Crystal, BG04
Bailey, Janelle M., BF09, PST1D04
Bailin, Jeremy, DD03
Baker, D. Blane, HB06
Banner, Jay, FK11
Bao, Lei, CC05, PST2B01, PST2B03
Barbato, Lyle, PST1E01
Barbosa, Heloisa G., AF04
Barr, John, HC09
Barr, Alex M., GI10
Bartley, Julie, BE06
Barton, Linda S., CD04
Bartz, Sean P., BB05
Bassante, Anthony, CC02, EF14, EF16, EF20, EF21
Bassante,, Anthony, EF09
Bayat Barooni, Amin, CK03, EJ05
Beach, Andrea, EM06, PST1E57
Bearden,, Ian, EF17, FB03, PST1A04, PST2B09, PST2B18
Beehler, Adam, W45
Behringer, Ernest, BB02, EH04, BB10
Bell, Anna, CC06
Belleau, Shelly N, BL05, BL08
Bennett, Michael, FI07, PST2D38
Berlinghieri, Joel C., BF06
Beverly, Nancy, GG05
Bhattacharyya, Kobi K., PST3A30
Bian, Youyou, SPS04
Black, Katrina E., PST3A25
Blaha, Cindy, DD02
Blakeney, Cody, PST1E03, PST2D34
Blanchard, Margaret, BL07
Blanchard, Alanna M., SPS15
Blankenship, Tyler, PST2B08
Blue, Jennifer, SPS17
Bodegom, Erik, EF03
Bogdan, Abigail M, DH04, AK01
Bohacek, Peter, FK12, HB03, GI11
Boisen, Axel, PST1A04
Bolander, Eric, SPS14
Bonham, Scott W, DF01, PST2B02
Born, Darrell, DG07
Bortner, Larry J., PST2B03
Boudreaux, Andrew, BJ02, BJ06, PST1B01, W20, BJ04, W28
Bourgeois, Paul, DG01
Boyd, Alexandra (Solender), EA02
Boyd, Nicole, GI05
Boyd Harlow, Danielle, FI06
Brahmia, Suzanne, W28
Brain, Duncan, HC08
Bravo Gallart, Sílvia, W24
Brecht, Nash, PST2D02, CE04
Bresges, Andre, EC06, GI09, W28, W04
Brewe, Eric, CK07, DL03, EB04, PST1E28
Briggs, Patrick R, BF06
Brookes, David, EK06, PST1E13, PST1E30, W13, BJ01
Brown, Benjamin, PST2D21
Brown, Casey, FM01
Brown, Erika E.A., GA01
Brown, Katrina, EI06
Bryan, Lynn A, PST1E33, FI02, FI03, FI01
Bugge, Danielle, BL06, PST1E40
Burciaga,, Juan, CG01
Burde, Jan-Philipp, AA02, PST2D47
Byrum, Amber, EM05
Caballero, Danny, PST2D07, W44
Caballero, Marcos, EH01, PST1D05, PST2D22, PST2D32, PST3A02, AK08, BB04, DL04, EJ01, PST1E21, PST2D12, PST2D40, EH03, BB09, W43
Cai, Bei, FB07
Callan, Kristine, FM02, EC02
Calleja, Misael, PST2D28
Callori, Sara J., CC04
Caravez, Daniel, DA02, PST1E59, FH01, PST1E14
Caravez, Nancy, DA02, FH01, PST1E14, PST1E59
Carroll, Patrick J., SPS17
Carter, Ashley R., AD03
Casselman, Brock L, EB02
Catao, Andre, PST2B14
Cervenec, Jason, BE01
Chabay, Ruth, CF01, W42
Chambers, Timothy, FF04
Chandrasekhar, Meera, FJ05, SPS08
Chaney, Robert A., DI03, PST2B23
Chari, Deepa N., AG02
Chastain, Raymond, DG02
Chasteen, Stephanie, FL01, FM04, PST1B01
Chen, Kui, BL03, PST2A05
Chen, Zhongzhou, CK09
Cheng, Jiale, SPS03
Chessey, Mary K., BK03
Chini, Jacquelyn, CL04, FK06, PST1E15, PST1E44, EJ05, CK01, PST1E54
Cho, Shinil, HB01
Chonacky, Norman, PST1D05
Chonacky, Norman J., EH03, BG01, EH01, W44
Chow, Celia Chung, BE04
Christensen, Warren, BJ08, GG03, PST1E63, PST2D04, PST2D09
Christian, Wolfgang, CE05, CE02
Churukian, Alice D., CI08, W12, W02
Cid, Ximena, DH01, BF09, GA02
Cise, John P., EE04
Clark, Erica, PST1E58
Clark, Ted M., EI03
Clarke, James, W40
Cline, Troy D, BF10
Close, Eleanor, BI05, CJ11, FM05, PST1E38, PST1E39, PST1E58
Close, Hunter G, PST1E03, PST2D34
Close, Eleanor W., FM06, ED01
Cochran, Geraldine L., GA01
Cole, Renee, EM04
Colesworthy, Peter, CJ07, PST2D41
Collins, Aaron, FM05
Collins, Aaron C., FM06
Compass Project, ED03
Concannon, Thomas, PST1B06
Concannon, Kristi D., PST1B03
Conn, Jessica, FM05, FM06
Conway, Matthew J., SPS08
Cook, Monica, CK03
Corbett, Katelin, CH06, CH08
Corbo, Joel C, PST2C03, AL03
Corcovilos, Theodore A., DH03
Cordry, Sean M., HB04
Corne, Matt, PST2D10
Corpuz, Ma. Aileen A., PST3A12
Corpuz,, Edgar D., PST3A12
Countryman, Colleen, AA03, W04
Coutu, Clayton B., FB02
Cox, Monica F., AI03
Cox, Anne J., DD02
Craig, Matthew, CF03
Cronin, Nicole, EF09, EF14, EF20, EF21, CC02, EF16
Crouch, Catherine H., DL07, PST2D54
Croyle, Kevin, GI08
Cui, Xintu, DI07
Czarnecki, Andrzej, FB02
D'Urso, Brian, W17
Daane, Abigail, SPS14, CH03, PST1E19
Daane, Abigail R., BG02
Dancy, Melissa, DD03, EM01, EM02, PST1E07
Dark, Marta L., AD09
Dasgupta, Chandan, PST2A02
Davenport, Felicia, PST1E05, PST1A02
Davies, Chad L., AC05
De La Torre, Angelica, DA02, FH01, PST1E14, PST1E59
DeCaro, Daniel, DG02
DeCaro, Marci, DG02
DeLaney, Tracey, PST3A20
DeLeone, Charles Joseph, DH02
DeSerio, Robert, EF05
DeVore, Seth, PST2D37, BI02, PST1E17, PST2D29, PST3A01
DeWeerd, Alan J., CF04
Deane, Jessica, CH02
Deardorff, Duane, W12, CI08
Decker, Sierra, SPS14, CH03, PST1E19
Della-Piana, Connie K., FK10
Denicolo,, Glenda, PST1D06, PST2B17
Denisova, Katya, EA04, EC04
Dennis, William M., AG03
Deremer, Charles P., BA03
Desbien, Dwain, BH02, W19
Devore, Seth, PST1E32
Dey, Sajalendu, HC09
DiLisi, Gregory A., CI07
Diaz, Oscar, DG04, PST1E29
Dickie, Steve, FG02
Ding, Lin, AK05, CK02, EI03, PST1E52, PST1E53
Dittrich, William A., BF03, PST2D44
Dizon, Reggie, PST2D27
Docktor,, Jennifer, BL01, PST2A07
Dolan, Michael, PST2D13
Dollar, Franklin, PST2D33
Doluweera, D. G. Sumith P., AK06
Donaldson, Nancy, GG02
Donev, Eugenii U., PST2B08
Dong, Siqi, SPS12
Donnelly, Dermot, HC01
Dontje, James, BE06
Doty, Sandra L., PST3A09
Dou, Remy, CG03, DL03
Doucette, Danny, W07
Doughty, Leanne, DA01, PST2D51
Douglas, Scott S., EJ03
Dounas-Frazer, Dimitri R, ED04, PST2D39, GA03, PST2B06
Doyle, Jacqueline, FA02
Drosd, Robert, PST2D44
Duda, Gintaras, PST2C02
Dudley, Colton K., EF01
Dudley, Scott C., EF01, EF01, PST2B14
Duffy, Andrew G., EI01
Duman, Timothy A., FB04
Duncan, Douglas, BF02
Durfee, Dallin S., DI06
Easterly, Nancy J., DD01
Edwards, Andrea, PST2B07, DI02
Eichenlaub, Mark, BI01, PST2D48, BI11
Eidelman, Dave, GI10
Ekey, Robert Charles, DI02, PST2B07
Elby, Andrew, DL02
Eldar, Osnat, FJ06
Ellis, Terry, FK08
Emigh, Paul J., EK04, W21
Engelhardt, Larry, BB13, W44, PST1D05
Engelhardt, Paula V., FI05
Engelman, Jonathan A., GI04
Engels, Robert J, BA04
Ergueta, Patricia Bilbao, HA08
Ertl, Christopher, DG01
Etkina, Eugenia, BJ01, BL06, EK06, FJ01, PST1E13, PST1E40, PST1E55, W13
Euler, Elias, EJ06, PST1E43
Evans, William R., CC03
Falconer, Kathleen, PST1B08, PST1D01, EC06, W39
Fang, Yizhong, DI07
Farlow, Brian, PST1E63, BJ08, PST2D04
Feldman, Gerald, CK01
Fender, Josh, PST3A26
Feng, Raohui, DI07
Ferm Jr., William N., BJ10
Ferriera, Jocelyn, SPS14
Fictorie, Carl P, DF03
Fiedler, Brett, FI07, PST2D38

Finkelstein, Noah, PST1E42, FI07, PST2D38, PST2D45
Fiser, Briana L., DG05
Flaten, James, BF05, BF07, W27
Foote, Kathleen T., HB05
Forinash, Kyle, CE05
Fortin, David, FB02
Foutz, Timothy, AG03
Foxley, Ansel, BL03, PST2A05
Fracchiolla, Claudia, AF02, EM07, PST1E42, PST2D38, PST2D46
Franklin, Scott, CH05, FH03, GH01, GH02
Franklin, Max, PST2D54
Fratiello, Paul, FG01
Freeman, Mark, FB02
French, Richard M., PST2A08
French, Debbie A., PST2A08
Friel, Eileen D., AE02
Fritz, Linda, DD02
Frodermann, Evan, BG03, DE01, PST1D09
Froyd, Jeff, EM04
Funkhouser, Kelsey M., EJ01, PST2D22
Gaffney, Jonathan, PST1B01
Gallart, Silvia Bravo, W24
Gallegos, Benjamin, CL04
Gambrell, Justin E., PST1E04
Gauthier, Alexandre, PST1E17
Gearen, Michael, W40
Gearhart, Brad, PST1D01, PST1B08, W39
Geille, Pablo, PST1B07
Gelderman, Richard, BF01, BF08, EE02, GF01
Geller, Benjamin D., PST2D54, DL07
Genz, Florian, CH05, EC06, FH03, W39
Gerving, Corey S., EC07
Gette, Cody, BJ03, BJ04, PST2D30, BJ02, PST2D31
Giesbrecht, Grant, PST3A11
Gifford, Julian, PST2D45
Gilbert, Dennis, DD05
Gilliam, Shon, PST3A15
Giordano, Gerardo, PST1B06
Gire, Elizabeth, FK04, FK07, GH04, GH05, EK07, PST1C04
Gitomer, Drew H, FJ01
Gladding, Gary, CK11, CK10
Glazenburg, Zhanna, EA03
Glover, Marla Jane, AB02
Goldberg, Fred M., FI04, PST2A04
Golden, Donnie, HC01
Gollapinni, Sowjanya, AB01
Gomes, Maria Ruthe, AF04, PST1A01
Gonzalez,Wilson J., PST1B07
Good, Melanie, FK09
Goodhew, Lisa M, CJ01, PST1E11, PST1E31, CJ02
Gould, Scot, GG01
Graham, Natasha, GH01, GH02
Greco, Edwin, EJ03
Green, Adam S, BB01
Green, Chrystin E., PST1E50
Greene, Michael, DH01, FJ04
Greenman, Mark D., GI07, PST1A06
Greenslade, Jr., Thomas B., FC02
Gregorcic, Bor, EF12, EJ06, FK03, PST1E43, PST1E56
Grosz, Nathanial, BJ04, BJ02, BJ03
Grove, Timothy T, W05, AD06, PST2B13, PST2B16
Gruesbeck, Marta, DI03, PST2B23
Gu, Yu, PST1E20
Guo, Xing, SPS13
Gupta, Ayush, AK07, PST1C12, PST2D45, AI01
Gust, Eric, GI05
Guthrie, Matthew, PST1E18
Gutmann, Brianne, CK11
Guzey, Selcen, FI01
Hairston, Tali, BG02, W37, W02
Hall, Jonathan C., AF03
Hamilton, Kathleen, GI10
Hanuscin, Deborah L., EC05
Harber, Catherine, PST1E37
Harder, Riley, DL01
Haritashya, Umesh, BE02
Harlow, Jason J.B., EM12
Harper, Kathleen A., EI03
Harrison, David M, EM12
Hartley, Laurel, DA01, PST2D51
Hatch, Heath, DG01
Hauser, Austin, EI05, PST1B09
Hauze, Sean, PST2A08
Hawkins, Nathaniel T., PST2D40
Hazari, Zahra, BK02, HA04
Hazelton, Ryan L C, CK05
Hechter, Richard P., EE06
Heckler, Andrew, AG04, EM05, AG01, AK05, CJ04, DH04, FJ03, PST1E34, PST1E52, CK02, EK03
Heijkenskjöld, Filip, EF12, FK03, PST1E56
Heinke, Heidrun, HB09, PST3A03
Heimburger, Joey, W39
Heise, Gary, PST3A07
Helgason, Thordur, PST2B15
Heller, Ken, BG03, DE01, PST1D09
Hemingway, Deborah J, BI11, BI01, PST2D48
Hemmick, Thomas, CC02, EF16, EF20, EF09, EF21, EF14
Henderson, Charles, DL05, EM02, EM06, PST1E02, PST1E07, PST1E24, PST1E57, PST2A01, EM04
Henderson, Rachel, EK02, FH02, PST1E32
Hengesbach, Jeffrey, BA01
Hennes, Erin P., BE03
Henning, Steven L, EA04
Herne, Catherine, AD08
Heron, Paula R L, CJ01, PST1E11, CJ02, PST1E31, FL02, W20, W40
Herrera, Xochith, BI05, PST1E39, CJ11, PST1E38
Hertel, Josh, PST2A07
Hesaaraki, Shahrzad A., FM06, FM05
Hezseltine, Matthew R., SPS09
Hilborn, Robert, EH01, PST1D05, EH03
Hilleke, Russell O, BF06
Hinde, Anthony, HC01
Hinko, Kathleen, PST1E42, PST2D11, FI07, PST2D38, EM07, AF02, PST1A09, PST2D46
Hobbs, Robert, PST2D39, AD07
Hodapp, Theodore, CH01, GA01
Hoehn, Jessica R., PST2D45
Hohertz, Jeremy D., PST3A15
Holbrow, Charles H., AC04
Holley-Bockelmann, Kelly, AE01
Holmes, Natasha G., PST2D36, BI06
Holsenbeck, Elizabeth, CA01,
Horna, CarriEve A, PST1E27
Horner, Lenore, HA06
Hou, Jixuan, SPS16, SPS05
Howell, Joshua, PST2D25
Hsu, Leon, DE01, PST1D09, BG03
Huber, Thomas, BE06
Hull, Michael M., DG06
Humphrey, Bridget, EM08
Hunt, Doug, PST2A08
Hutson, John, FK01
Huynh, Tra, GH07, GH08
Hyater-Adams,, Simone, ED04, PST1E42
Hynes, Morgan, AI02
Hütz, Simon, HB09, PST3A03
Ibrahim, Bashirah, CK02, AK05, PST1E52, PST1E53
Insulla, Francesco, EF01, PST2B14
Iordanova, Aneta, CC02, EF09, EF14, EF16, EF20, EF21
Irons, Stephen, W02
Irving, Paul, EM10, PST2D07, PST3A02, AK08, PST1E21, PST2D40, BB04, PST2D32
Ives, Joss, PST2D53
Jackson, David P., DC01
James, Westley, PST1E54, CL04
Jammula, Diane, BK04, CH02
Jariwala, Manher, BI05, PST1E39
Jeffery, Rondo N., CI05
Jenkins, Ben, PST2B05
Jensen, Erik, EF03
Jeremiason, Jeff, BE06
Jhun, Youngseok, DE06, PST2D03, DE06, PST1E06
Ji, Min, EF07
Jiriwala, Manher, CJ11, PST1E38
Johns, Bethany, FE01
Johnson,William S., BJ10
Johnston, Marty E, BB01, BB07
Jones, Brian, GG06
Jones, Dyan, SPS11
Jones, Kolton, PST2B02
Jones, Matthew I, AK04
Jung, Hana, GI02
Justason, Michael, EM12
Justice, Paul, BI03
KK, Mashood, FH05, PST1B02
Kaar, Taylor, BA04
Kabir, Ahsanul, PST2B08
Kalender, Yasemin, AL04, AL05
Kanim, Stephen, W28
Karim, Nafis, EB06, CJ06
Kashinski, David O, EC07
Keebaugh,, Christof K., EK10, PST1E22
Keeports, David, DE04
Keil, Jennifer R., HA01
Kelly, James G., PST3A29
Kelter, Paul, DL06, PST2D50
Kennedy, Matthew, EI03
Kepple, Caitlin, PST2D09
Key, Roger A., HC01
Khan, Damian, EI07
Khatri, Raina, EM04, PST1E02
Kim, Jungbog, PST2D18
Kim, Eun Hee, PST2C04
Kim, Jiye, PST2D03
Kim, Jung-Bog, BL04
King, Karen E.L., EC05
Kinnaman, Laura, EC08
Kippley, Brett R., CJ10
Klein, Pascal, EL02, AA01, W04
Klinger, Rachelle, EI05, PST1B09
Klingler, Noel, CK01
Knaub, Alexis, DL05
Knobel, Robert, FB07
Knowles, Arlene M., BG02, W02
Koenig, Kathleen, CE03, PST2B03, CC05, PST2B01, EC01, GI06
Koenka, Alison, EM05
Kohl, Pat, PST3A10
Kontro, Inkeri, PST3A13
Kornick, Kellianne, GH01, GH02
Kornreich Leshem, Hagit S, PST1E29
Kosztin, Dorina, FJ05, SPS08
Kozminski, Joseph F., BE05
Kraft, David W., HA03
Kramer, Laird, DG04
Kramer, Laird H, PST1E29
Krause, Eduard, EL03
Kryjevskaia, Mila, BJ02, BJ05, BJ11, DL06, PST2D31, PST2D50, BJ03, PST2D30, W20
Kuhn, Jochen, AA01, W04, EL02
Kuo, Vincent H., PST3A10
Kustusch, Mary Bridget, CH05, FH03
Kutal, Charles, AG03
Kwon, Patrick J, EM11
Ladbury, Jared, DL06, PST2D50
Lafranconi, Hanna, EM05, AG01
Lancaster, Jarrett L., GH10
Landay, Justin, AK03
Lane, W. Brian, FK08
Lang, Jillian, EF15
Langdon, Laurie, DA03, EB05
Larson, Adrianne N., BL03, PST2A05
Larson, Shane L., FF02
Lattery, Mark J., CJ09
Lau, Alexandra, EM02, PST1E07
Lauterburg, Urs, FG03
Laverty, James T, PST2D24, W43, CJ10
Laws, Priscilla, GI06, CE03, W34,
Lazo, Shannon Dumphy, CL01
Le, Paul, DA01, PST2D51
Le, Yongkang, EF07
Le, Thanh K., AK02
LeBlanc, Lindsay, FB02
LeDocq, Mike, PST2A07
Leak, Anne, AH03, EK05, FK02
Leary, Ashleigh N., PST2D07
Leblond, Louis, CC09, EF02
Lee, Gyeong Jin, BL04
Lee, Jiwon, PST2D18
Lee, Kevin M., FK10
Lee, Sooah, PST1E06
Leif, Todd R, BH03
Lenz, MacKenzie, FK04
Leonard, Dakota, HB01
Lerner, Michael E, W03
Lerner, Michael E., BA04
Leshem, Hagit, DG04
Leslie-Pelecky,, Diandra, DB01
Levy, Jeremy, PST1E17
Lewandowski, Heather J, BI07, PST2D39, PST2B06, DI05
Lewis, Steven P., AG03
Li, Dexin, SPS07
Li, Jing, PST1E23
Li, Yinghui, SPS06
Li, Sissi L., BI09
Liao, Deju, DI07
Lieberman, Ido, GF02
Lietz, Martha, EA01
Light, Leslie, PST3A10
Lima, Isabelle Priscilla Carneiro, PST1A10
Lin, Ryan, EM11
Lin, Shih-Yin, EJ03
Lin, Yuhfen, W13
Lindaas, Steve, W45
Lindell, Rebecca, FH02, PST2D52, FH02, PST2D52, EF18
Linder, Cedric, EF12, FK03, PST1E56
Lindsay, William E, BL05, BL08
Lindsey, Beth, BJ04, BJ11, PST1E28, BJ06, W20
Lindstrøm, Christine, CL03

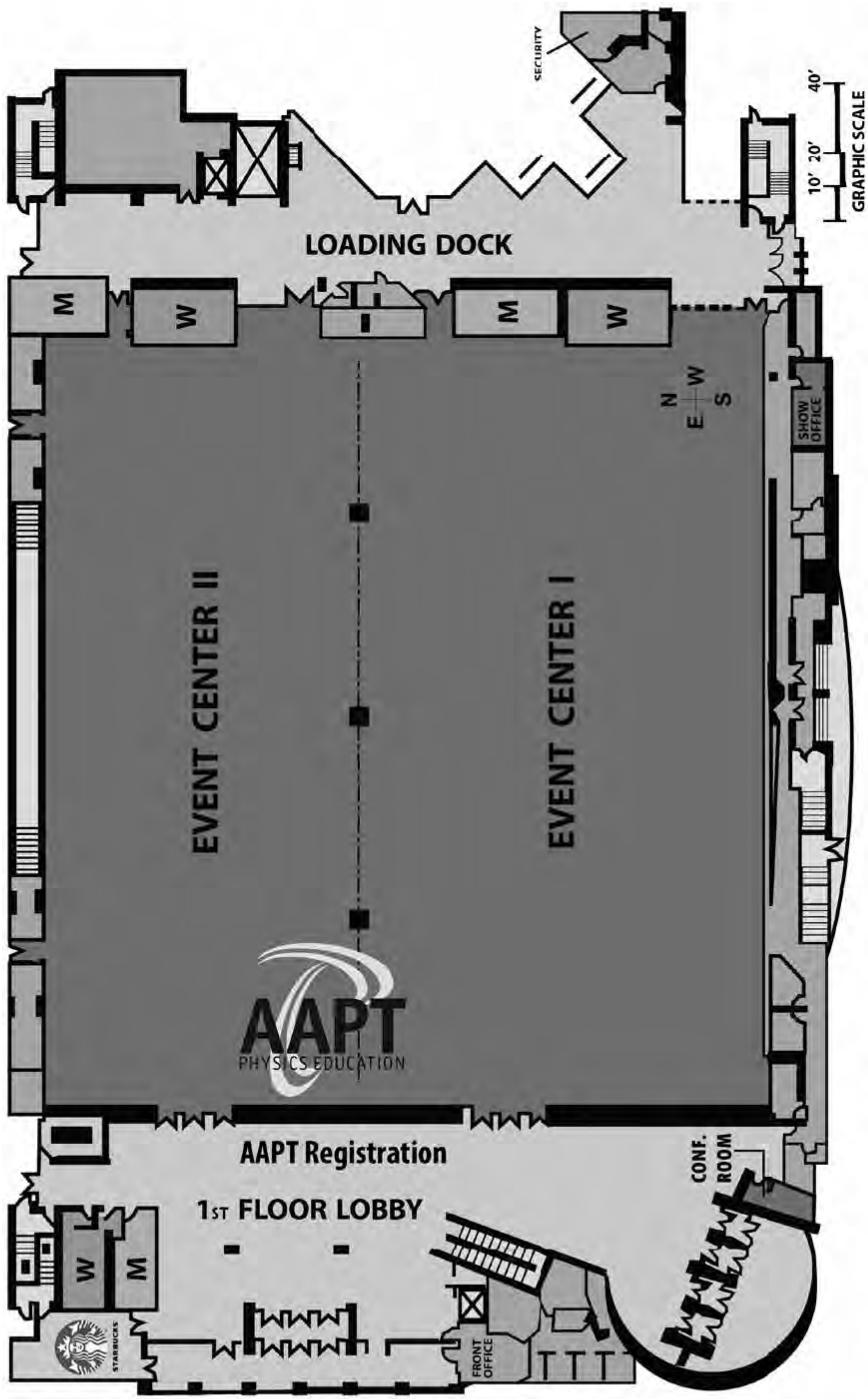
Little, Angela, CH04, ED03, EM08, PST1E26, W23
Liu, Zengqiang, FJ02
Lock, Frank D., AF01
Lock, Robynne M., BK02
Lockett, Philip, PST3A11
Lonnquist, Kenn J, W08
Lopez, Ramon E, FJ04
Lopez del Puerto, Marie, PST1D05, BB0,1 W44
Lopez, Mike A., AG01
Lopez, Ramon E., BF09, DH01
Loschky, Lester C., FK01
Loverude, Michael, BJ08, FF03, PST1E48, PST1E63, PST2D04, GH12
Lulai, Paul, EI04
Luna, Brian, PST2B02
Lupton, James H., EI07
Lusk, Mark, PST3A10
Ly, Sonny, PST1A09
Ma, Shihong, DI04, PST2D19
MacIsaac, Dan, PST1B08, W39, EC06, PST1D01
Madsen, Adrian, CG03, PST1E01, W35
Madsen, Jim, GF03, W24
Mae, Naohiro, DG06
Magana, Alejandra J, DE05
Maher, Pamela A., PST1D04
Mallmann, A. James, CI06
Maloney, David P., PST1E37
Mandell, Eric, EF06
Mangiaracina, Mike, EA04
Manogue, Corinne, EK04, AH02
Marcinkowski, Thomas J., CC01
Marder, Michael, FM01, PST1E18
Mardis, Kristy, PST1A02
Maries, Alexandru, CJ06, PST2D20, EB06, PST1C01, PST1C08, PST2A09, PST2A10
Marino, Mathew, CL04
Marino, Taylor, HA01
Marshall, Christopher, FG04
Marshall,, Jill A., FK11
Marshman, Emily, AL04, AL05, BI03, BI04, EK09, EK10, FK09, PST1E22, PST1E24, PST1E46, GH09, PST1C10, PST1C11, PST2A01, PST2D37
Martin, Kelly, AH03, EK05, FK02
Martinez, William M., DL04, PST2D12
Martins, Julian S, BL08, BL05
Martinuk, Mathew, CG02
Martsberger, Carolyn M., CI02
Mason, Andrew J., EM09
Massey-Allard, Jonathan, PST2D53
Masters, Mark F, W06, PST2B04, PST2B20, PST2B25
Mayo, Louis A, BF10
Mays, Mikayla N., PST1E48
McCann, Lowell, GF03
McCaskey, Timothy L., PST1A07
McCormack, Stacy, HB02
McCoy, Bradley K., DF02, PST1E16
McCullough, Roy, PST2B07, DI02
McDonnell, Jordan D., BB13
McEwen, Megan, EI10
McInerny, Alistair G., DL06, PST2D50
McIntosh, Gordon, BF07
McKagan, Sarah B., PST1E01,W35
McMillan, Taylor, PST3A07
McNeil, Laurie E., CI08
McPadden, Daryl, CK07
Mecca, Stephen J., EF04, GI05
Meltzer, David E., AK04
Menon, Deepika, SPS08, FJ05
Merner, Laura, EH01, EH03, EH02
Merrell, Duane B., EC03, W30
Messina, Troy C., CC07
Mestre, Jose, BL01, CK10, EM11
Meyer, Helen, EC01
Meyertholen, Andrew D., EM12
Michaluk, Lynnette M, PST1E32
Mikula, Brendon D., FJ03
Milbourne, Jeff, EA03
Millay, Laura, CJ08
Milliman, Hannah, PST2B14
Millspaw, Jacob, PST2B20, W06, PST2B25, PST2B04
Milne, Michelle, PST2D26, PST3A27
Milton, Judy, AG03
Minkin, Leonid, PST2D44
Mitchell, Brandon, PST2B07, DI02
Mo, Jinwoo, PST2D18
Modir, Bahar, GH03
Mohr, Peter J., AC01
Moore, Emily B, CE01
Moore, Kimberly A., CI09, PST1E47
Morgan, Patrick R, FI08, PST1A03
Morgan, Windsor, W14
Morphew, Jason W, EM11, CK10
Morse, Justin, PST3A26
Morse, Robert A., AC03
Mota, Luzia Matos, PST1A10
Mrozowska, Marta, PST1A04
Mueller, Sara M., AG04
Munchrath, Alexis, PST2C02
Mungan, Carl E., DB02, PST1C09
Murray, Jeffrey W, PST2C01
Mylott, Elliot, GG03, PST2D09
Nainabasti, Binod, PST1E30, PST2D25
Nair, Abhilash, EF08, EM10
Nakamura, Taku, PST3A05
Nascimento, Julio Cesar, PST1A01, AF04
Nasim, Amreen, PST2D51
Nasser, Luis, PST1A07
Near, Jim, BF06
Nelson, Philip, W33, GH06, PST1C02, PST1C03
Nelson, Peter Hugo, CI10
Nelson, Tobias A, PST1C05
Nevidomskyy, Andriy, HA08
Ng, Carolyn, BF10
Nichols, Daniel H., FB05
Niederriter, Charles, BE06
Nissen, Jayson, CJ11, DA02, FH01, PST1E14, PST1E38, PST1E59, BI05, PST1E39
Nokes-Malach, Tim, AL05, AL04
Nolte, David, AH01
Nord, Paul M, W02, T01, W02
Nyaema, Mary K., DG04, PST1E29
O'Kuma, Thomas L, W19, BH01
O'Shea, Kelly, EA01, W07, ED02
Ober, David R, CI04
Obsniuk, Michael J., BB04
Odenwald, Sten, BF10
Oechsle, Jan, PST2B18
Ohlsen, Braden R, EB02
Ohmann, Paul R, BB01
Oldroyd, Will, CC06
Oliveira, Josileide Ferreira, PST1A10
Olmstead, Alice R., EM06, PST1E57
Olmstead, Matt, PST1B04
Olsho, Alexis RW, CJ05
Oncul, Ebru, PST3A16
Orban, Christopher, GI01, PST1E45, CE04, PST2D02
Orleski, Michael P., PST1E12
Otero, Valerie, DA03, EB05, BL05, BL08, DC02
Owens, Lindsay, PST2B03, CC05, PST2B01
Palma, Chris, W14
Papak, Alexis
Papanikolaou, Christos P, DH06
Paradigms 2.0 Team, The whole, AH02
Parker, Stephen C., DG07
Passante, Gina, EK08, PST1E50, PST2D28, W21
Patricio, Orlando M., CK06
Pawl, Andrew E., GI03, PST1D08
Pawlak, Alanna S., AK08, PST1E21
Pawlowski, David, BB02
Penido, Maria Cristina Martins,
Penn, Matt, BF01
Perciante, Daniel, PST1B07
Perez, Rosina, PST1B07
Perkins Coppola, Matthew P., PST3A18
Perkins, Katherine K., CE01
PhET Team, CE01
Pho, Myat Thinzar, EJ05
Piedrahita Uruena, Yuri, PST2A02, EJ02, PST2C01
Pierce, Michael, BF01
Plantt, Taylor, FM02
Plisch, Monica, CH01, FM02, FM04, FM01
Poelzer, G. Herold, PST1E10
Pollack, Linda B, BA04
Pollard, Benjamin, PST2D39
Pomian, Katarzyna, PST3A14
Ponnambalam, Michael J., DD04
Poodry, Fran, EA04
Popa, Gabriela, DG08
Porter, Christopher, AG04, EM05, GI01, PST1E45, PST2D02, CE04, DH04
Portuondo, Raul, EJ02
Potvin, Geoff, AG02, HA04
Powell, Bob, PST2B05
Powers, Nathan D., DI06, CC06
Prather, Edward, FF03, FF04
Price, Kent J., SPS09
Price, Edward, EM01, PST2A03
Proleiko, Igor V., EI09
Puchalla, Jason, GG04, PST2D01
Pundak, David, GF02
Qing, Gan, EF07
Quaal, Adam T., PST2D28
Quan, Gina, ED03, DL02
Quarderer, Nathan A., PST1D03
Quinn, Katherine, BI06, PST2D36
Rainey, Katherine, ED04, AL01, PST2C03
Raker, Emily, SPS11
Ramey II, Charles L., DH05
Ramirez, Brenda, PST3A12
Rao, Rolex, HC04, HC05
Rarick, Richard A., CI07
Rebello, N. Sanjay, PST2A02, PST2C01, FK01, FI03
Rebello, Carina M., FI02, PST2A02
Redish, Edward F, BI01, BI11, PST2D48
Redman, Jerry, PST2A07
Reed, Steven, PST1E30
Reeves, Mark, CG04
Reilly, Liam, EF04
Reinholtz, Daniel, ED04
Reiter, Erik, FK02
Reitz, William, PST2B07, DI02
Rhode, Katherine L., AE03
Riaz, Muhammad, CC01
Rice, Rex P., BA02
Richards, AJ, BJ01, PST1E27, EK06, PST1E13
Ringler, John, PST3A26
Roberts, Andrew, PST1D01, W39
Roberts, David Abbott, PST1D01
Robertson, Amy D, AL02, CJ02, PST1E31, PST2D16, BG02, CJ01, PST1E11
Robins, Ibraheem C., EJ05
Robinson, Sean P., CD02
Robinson, Stephen, FI06
Rodenborn, Bruce, PST3A11
Rodriguez, Idaykis, DG04, PST1E29
Rodriguez, Jeffrey A., BK01
Rogers, Adam Z, CJ08
Roll, Ido, PST2D53
Ronayne Sohr, Erin, PST2D45
Roos, Kelly, BG01, BB11, BB06, W44
Rosa, Katemari, FA03, AF04, PST1A01
Rosales, Daniel, PST2B08
Rosenblatt, Rebecca, PST2D42, PST2A06
Roudebush, Deborah, CC08
Ruch, Gerry, BB01, BB03, PST2B11
Ruggieri, Charles M., PST2D14
Rundquist, Andy, DD03
Rupright, Mark E., PST1C07
Rutledge, Carl T., BF04
Rutz, Eugene, EC01
Ryan, Gillian, DD03
Ryan, Qing Xu, EK08
Ryu, Minjung, FI03
Sabella, Mel, PST1A02, PST1E05
Sabo, Hannah C., DG03
Sadaghiani, Homeyra, EK08
Sahyun, Steven C., FG04, PST1B10, PST1D10
Salas, Jorge A., PST3A28
Saldanha, Jenifer, DL05
Salgado, Roberto B., PST1C05
Sammons, Amber R., PST2D27
Sampere, Sam, W22
Sanders, Nicolette, PST1A02
Santangelo, Brianna, EK05
Santos, Zackary, FK02
Santos, Sérgio Luis Pita, PST1A10
Sarasola, Marcos, PST1B07
Sato, Takashi, EF15
Saul, Jeff, EB03
Sault, Timothy, PST1E03, PST2D34
Saunders, Leonardo A., FB01
Sawtelle, Vashti, EF08, EJ01, EM10, FH05, PST1B02, PST1E04, PST2D22, W23, EM08, CI11, PST2D11, W23
Sayer, Ryan, PST2A01, BI04, PST1E24, PST2D20
Sayre, Eleanor, CH05, GH07, GH08, GH01, GH02, PST1E01, GH03, FH03, W35
Scanlon, Erin, EK01
Schatz, Mike, EJ03
Schermerhorn, Benjamin P., BJ07
Scherr, Rachel, FM04, W37, CJ01, CJ02, PST1E11, PST1E31, BG02, CH01
Schlamminger, Stephan, AC02
Schmidt, Laura, PST2D10
Schneider, Karl, EL01

Schreffler, Jillian, PST1E54
Schrode, Nicole, HA01
Schroeder, Daniel V., GH11, PST1C06
Schultz, Scott, EG01
Schunicht, Shannon A., HA02
Schunn, Christian, AL04, BL02
Schwartz, Jeremiah, PST3A07
Schwarz, Cindy, DB03
Scott, Brian, PST3A04
Scott, Emily, FH05, PST1B02, PST1E04
Scott, Tyler, DL01
Seeley, Lane, SPS14
Selen, Mats, EF19, EJ04, CC03, DI01
Semak, Matthew R., PST3A07, PST3A26
Serna, Gabriela, FF03
Seunarine, Surujhdeo, GF03
Shacham, Miri, GF02
Shaffer, Peter S., CJ05, W21, W40
Shapavolov, Alexander, PST2D44
Shemwell, Jonathan T, AK02
Shen, Han, DI07
Sherwood, Bruce, CF01, W42
Sievert, Pati A, T01
Sikorski, Tiffany-Rose, AK03
Simmons, James, DF04
Simmons, Kyle, CK03
Simmons, Nicole M, PST2C03
Simony, Paul, FK08
Singer, Tom, PST2A08
Singh, Chandralekha, AL05, AL04, BI04, CJ06, EB06, EK10, FK09, GH09, PST1C01, PST1C08, PST1C10, PST1C11, PST1E17, PST1E22, PST1E24, PST2A01, PST2A09, PST2A10, PST2D20, PST2D21, PST2D37, PST3A01, BL02, EK09, PST1E46, PST1E23, BI03, W32, W46
Skene, Braeden, HC08
Skoczelas, Brenda M., CI04
Slater, Stephanie J., W14
Slater, Timothy F., W14, EE03, T01
Smania-Marques, Roberta, AF04, PST1A01
Smith, Anthony, HB07
Smith, David P., CI08, W12
Smith, Donald Andrew, CI01
Smith, Emily, BG03 DE01, PST1D09
Smith, Joseph R., CE04, GI01, PST1E45
Smith, Joshua, FF03, PST2D02
Smith, Kaye L, BF07, BF05, W27
Smith, Sean, FI04
Smith, Trevor I., CJ03
Smith, Trey, EA04
Sneed, Terry-Ann, PST2D27
Soares, Marlon V., HB08
Sohr, Erin Ronayne, AK07, PST1C12
Sokoloff, David, DK02, W34, EF03, DK01
Soto, Patricia, PST2C02
Southey, Philip B., EK11, PST2D49
Spalding, Gabriel C., AD02
Speirs, J. Caleb, BJ05, BJ06, BJ10, PST2D30, BJ11, PST1E28
Spicklemire, Steve, CF02
Sridhar, Sam, AA03
Staacks, Sebastian, PST3A03, HB09
Stampfer, Christoph, HB09, PST3A03
Stanford, Courtney, EM04
Stanley, Jacob, DI05, PST2D39, PST2B06
Steffler, Matt, HC08
Steinhoff, Douglas, FJ05
Stelzer, Timothy, CK11
Stetzer, MacKenzie R, AK02, BJ02, BJ06, DH06, BJ10, BJ11, PST1E28, PST2D30, BJ04, BJ05, W20
Stewart, Gay, PST2D52
Stewart, John, BI02, EM03, FH02, PST1E32, PST2D06, PST2D29, BI02, EM03, FH02, PST1E32, PST2D06, PST2D29, DC03, EK02
Stiles, Timothy A., CI03
Stille, Dale, W22
Stober, Rebecca, HA01
Strong, Eric, EI08
Sturm, David E., AD01
Stuver, Amber L., FF01
Styer, Daniel, FC03
Su, Weifeng, DI05
Sudhakaran, Gubbi, PST2A07
Sutherland, Erin
Tabachnick, Elijah, CJ07, Elijah, PST2D41
Tadday, Ralph, PST3A23
Taffe, Heather, BL03, FM02, PST2A05
Tagg, Randall, CD01
Talbot, Robert M, PST2D51, DA01
Taniguchi, Masa-aki, DG06
Tao, Xiuping, AK09
Taylor, Beverley A. P., W18
Taylor, Philip, FC01
Teeling-Smith, Richelle, PST2D02, CE04
Teese, Robert, GI06, CE03
Thacker, Beth, DH05, BJ09
Theberge, Chayenne, HA01
Thees, Michael, EL02, W04
Thomas, Brooks, PST3A30
Thomas, Cathy N., EC05
Thomas, Frederick J., DI03, PST2B23
Thomas, Scott A, PST2B24
Thompson, Amreen N, DA01
Thompson, John R, BJ07
Thompson, Kristen, PST1A08
Thoms, Brian D., PST3A16
Thomsen, Marshall, BB02
Thornton, Ronald K, DK01, DK02, W34
Tillotson, John, FF03
Titus, Aaron, W42
Tobias, Sheila, HA07
Toggerson, Brokk K., DG01
Tolmie, Jessica, PST2D27
Topdemir, Zeynep, PST3A16
Tosa, Sachiko, AL06
Traxler, Adrienne, DD03, FH02, DD03, FH02, FA01
Trimble, James E, EC07
Trivedi, Monark, HA03
Tsobanjan, Artur, PST1D02
Tucker, Laura J., CK04, PST2D33
Tuggle, Demetrius, PST2D02
Turpen, Chandra, AL03, DL02, EM01, PST1E26, CG03, CH04, W23
Tøt, Alexander, EF17
Uglebjerg, Louisa, PST2B09
Underwood, Sonia, FH05, PST1B02, PST1E04
Van De Bogart, Kevin L., DH06
Van Dusen, Ben, BI05, FH01, PST1E14, PST1E39, PST1E59, DA02, CJ11, PST1E38
Van Duzor, Andrea, PST1E05
Van Garderen, Delinda, EC05
Vasquez, III, Eleazar, PST1E54
Vega, Marlene, BJ08, PST2D04, PST1E63
Ventura, Katherine C., PST2D24
Vesenka, James P., EF18
Vignal, Michael, FK07
Vokos, Stamatis, FM03
Volkwyn, Trevor S., FK03, EF12, PST1E56
Von Korff, Joshua S., CK01, EJ05, CK03
Vonk, Matt, GI11, FK12, HB03
Wagner, DJ, EE05, PST1E61
Wagoner, Kasey, PST2D01
Walker, John, PST2B11
Walker, Lucas G., HC03
Wallace, Colin S, FF04, CI08 W02, W12
Walsh, Kenneth C., CK08, PST1E41
Walter, Donald, BF01
Walter, Paul J., HC07
Wang, Hui-Hui, FI03
Wang, Jay, BB08, BB12
Wang, Jianlan, HA04
Wang, Siqi, PST2D19
Wangberg, Aaron, EK07, GH04, PST1C04, GH05
Wangberg, Robyn, EK07, PST1C04, GH04
Warble, Kelli, EA03
Waterson, Alyssa C., PST3A02
Weatherford, Shawn A., EF05
Weaver, David, W19
Weaver, Joanna, DG02
Webb, David J, BK03
Weliweriya, Nandana, GH08, GH07
Wellington, Theo, BF08
Welsch, Dylan, HB06
Welsh, Gail S., FH04
Wen, Yanyan, EF07
Wheeler, Samuel, BL07
White, Daniel, CK02
White Brahmia, Suzanne, PST2D14, W28, EB01, FK05
White, Gary D., AK03
Whitten, Barbara, DD02, PST3A30
Widenhorn, Ralf, GG03, PST2D09
Wiegert, Craig C., CF05
Wieman, Carl, BI06, PST2D36
Wiest, Joseph E., HC02
Wilcox, Bethany R., BI07
Wilcox, Matthew, CK01, FK06, PST1E44
Wild, Steven, PST1E51
Wilhelm, Thomas, AA02, PST2D47
Willard, Kathleen L., EI02
Williams, Don, HC01
Williams, Eric A., DL03
Williams, Jeremiah, W38
Williams, Karen A., AD05, PST1B05, PST3A04
Williams, Martin, HC08
Williamson, Kathryn, PST2D06
Willoughby, Shannon D, BF09
Wilson, Brian, EM12
Wilson, Thomas E., HC06
Winch, David, BG01
Winton, Mackenzie E., PST2B14
Witt, Matthew, BK02
Wittmann, Michael C, CJ07, PST2D41, CJ08
Wolf, Steven F., PST1E03, PST1E58, PST2D34
Womeldorf,**, Carole A., HA07
Wood, Krista, PST2B03, BH04
Wood, Laura A., PST2D16, AL02
Wright, Richard, PST2D13
Xie, Tian, SPS07
Xie, Zhenxiong, SPS02
Xiong, Zeben, DI04
Xu, Wenhan, SPS06
Xu, Yixin, SPS07
Yan, Ge, SPS10
Yang, Jie, BG03, DE01, PST1D09
Yang, Yuehai, PST1E30
Yasuda, Jun-ichiro, DG06, PST2B12
Yerushalmi, Edit, FK09, PST1E24
Yestrebsky, Cherie, PST1E54
You, Hye Sun, FK11
Young, Alex, BF10
Young, Chadwick H., PST1D12
Young, Nicholas, EK05, CJ04, PST1E34
Youngseok, Jhun, GI02
Yu, Heather, PST1E51
yuan, rui, SPS10
Yuan, Yuan, EF07
Yuksel, Tugba, DE05, PST1E33
Zabriskie, Cabot, EM03, PST2D06
Zamarripa Roman, Brian, PST1E15
Zamora, Ryan J., FM06, FM05
Zanfardino, Sara M, SPS17
Zangler-Scaduto, Chris, EF09, EF14, CC02, EF16, EF20, EF21
Zeng, Liang, PST1E10
Zhao, Yiping, AD04
Zhong, Hui, SPS01
Zhou, Changgong, BI10
Zhuang, Zhuang, BJ09
Zhuo, Danyuan, SPS07
Zich, Raymond, PST2A06, PST2D27, PST2D42
Zimmerman, Todd, DE03, PST2D10
Zingale, Michael A, PST1D06, PST2B17
Zisk, Robert C., FJ01, PST1E55, W13
Zohrabi Alaee, Dina, GH01, GH02
Zu, Tianlong, FK01
Zurcher, Ulrich, CI12
Zwart, John W., DF03
Zwickl, Benjamin, EK05, FK02, AH03
Zwolak, Justyna P., DL03, EB04
de Araujo, Zandra, EC05
ma, yiling, SPS10
van Zee, Emily, AH02
á Brúnni, Kristian, EF17

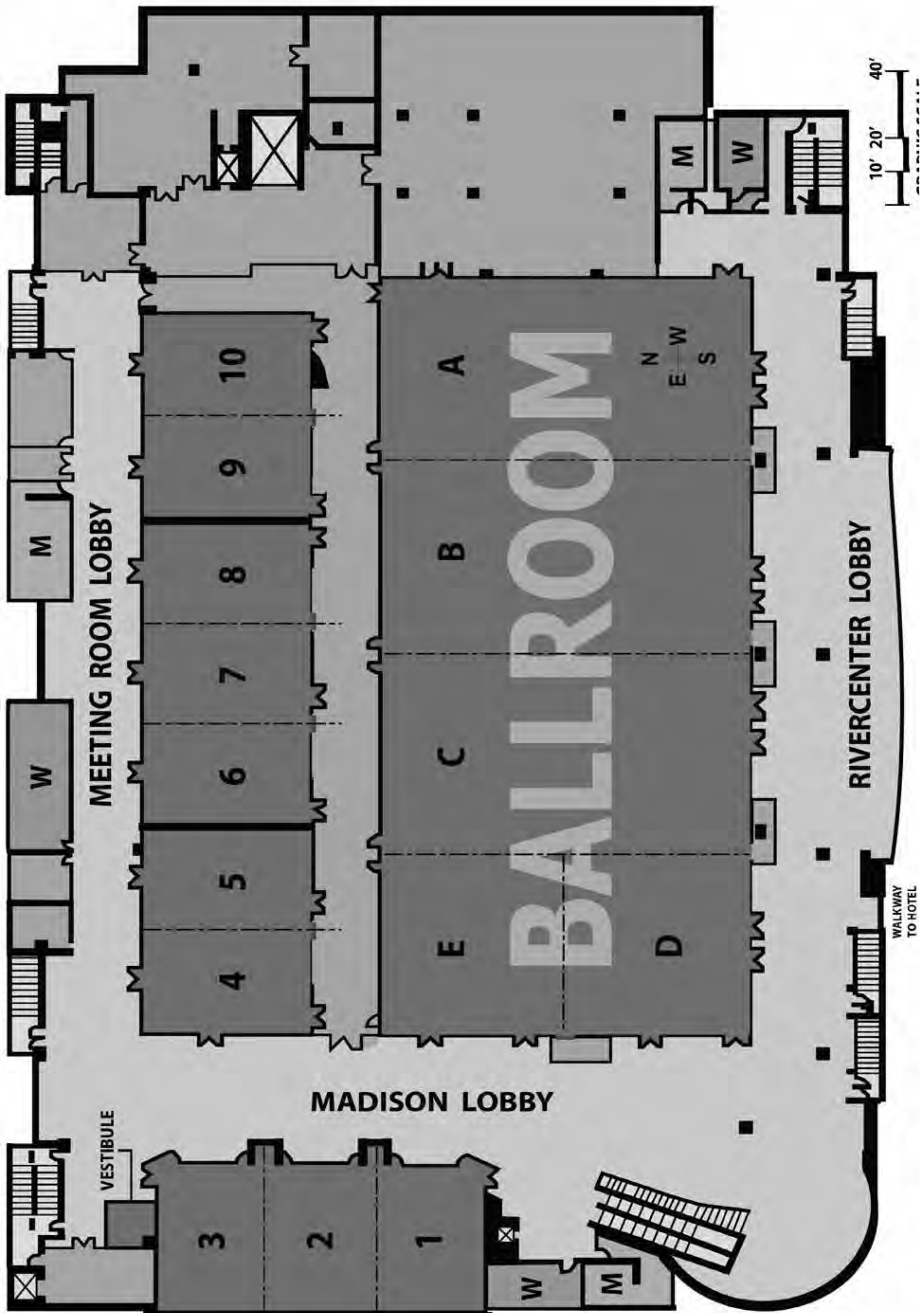
Index of Advertisers

Expert TA........................3,11
OpenStax..................1, inside back, inside front, 152
PASCO.................... Back Cover
PhysTec...............................38

Northern Kentucky Convention Center 1st floor



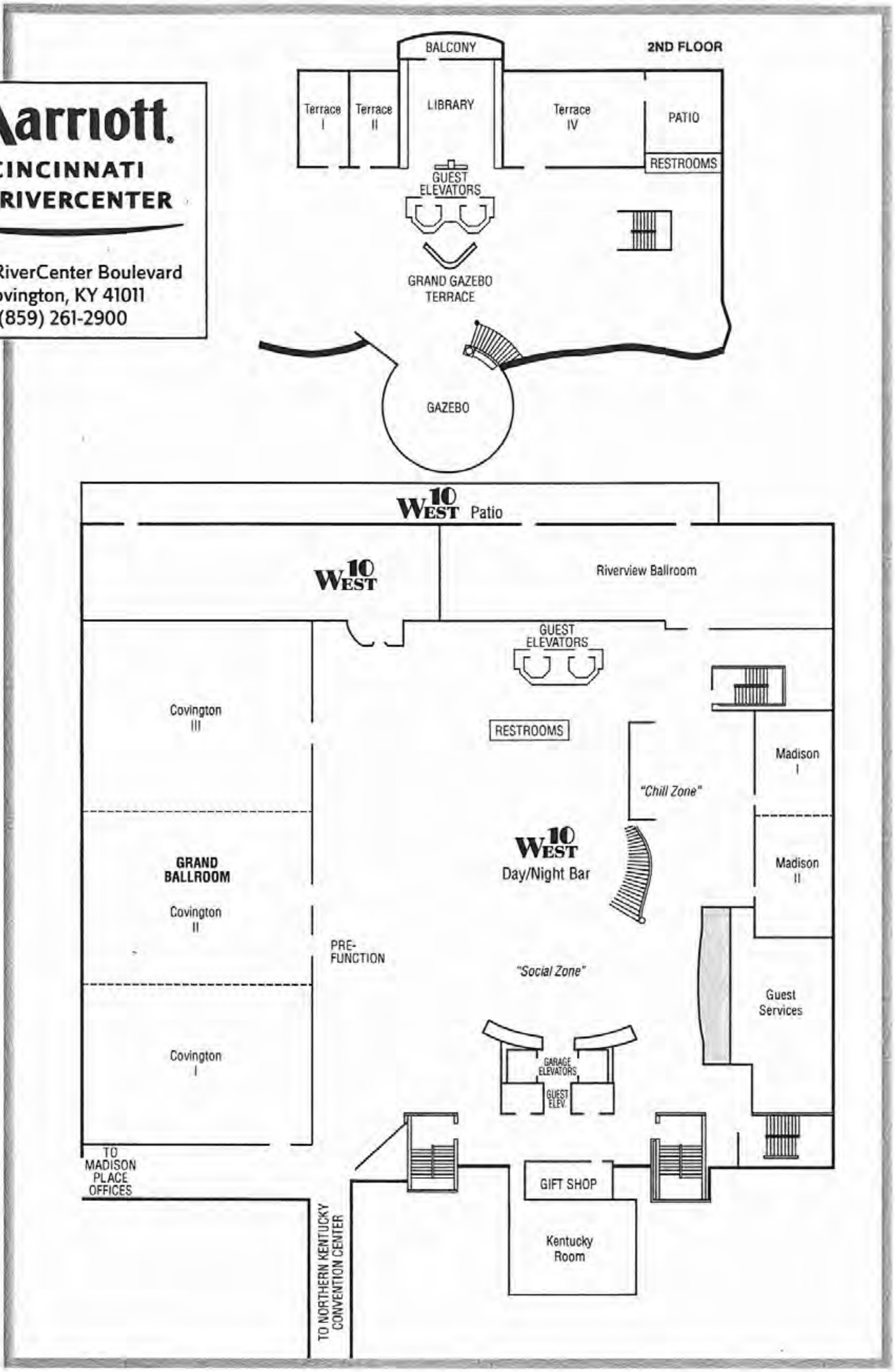
Northern Kentucky Convention Center conf. level



Marriott

CINCINNATI AT RIVERCENTER

10 W. RiverCenter Boulevard
Covington, KY 41011
(859) 261-2900



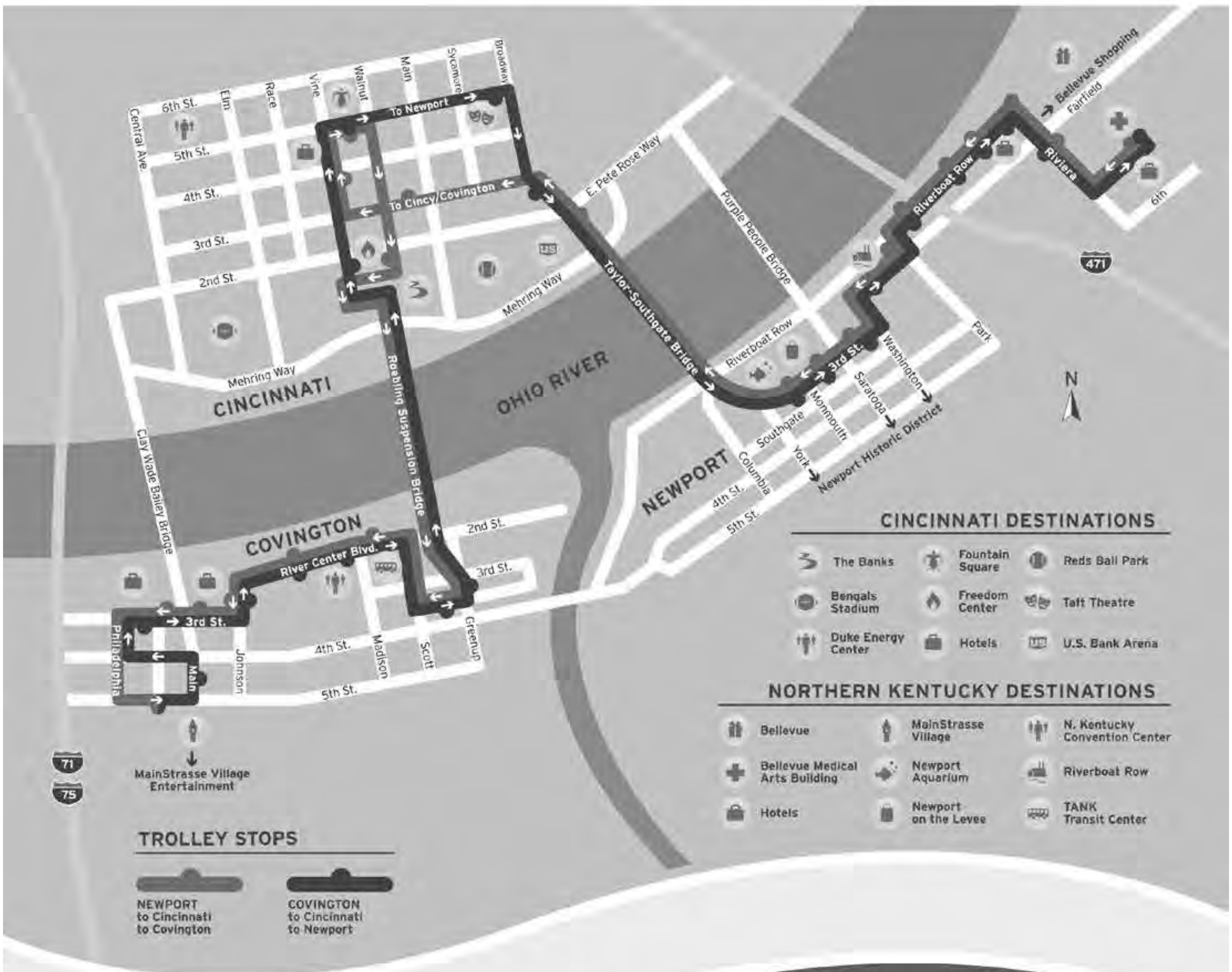
AAPT American Association of Physics Teachers

2017 AAPT Social Media Guidelines for Meetings

The American Association of Physics Teachers (AAPT) welcomes the use of social media (Twitter, Facebook, Google+, blogs, etc.) at our meetings. In order to make the meeting a safe and comfortable space, we set forth the following guidelines for social media:

- AAPT is committed to respecting the dignity of others and to the civil and thoughtful discussion of new and opposing ideas on social media. If you voice a complaint or disagree with a post, please do so in a polite and constructive manner.
- When tagging the American Association of Physics Teachers, please use our twitter handle @ AAPTHQ, or the meeting hashtag.
- We ask you do not post material that is harassing, abusive, or discriminatory to any other person.
- Please keep your posts relevant to the meeting, and do not post on our pages or tag us to promote businesses, causes or political candidates. AAPT reserves the right to report and/or remove any comments/tweets that are not relevant, discriminatory, etc.
- Keep in mind AAPT's Event Participation Code of Conduct and apply it to your communication online (and in person!).
- While the default assumption is to allow open discussion of presentations on social media, please respect any request by a presenter to not disseminate the contents of their talk.
- If you are presenting and do not want certain presentation slides or posters shared on social media, the icon above may be used on slides or posters. Please include the icon on each slide you wish not to be shared to ensure your preference is known (since people may come in after your presentation begins):
- Thank you in advance for following our guidelines.

SOUTHBANK SHUTTLE TROLLEY ROUTE MAP



SUMMER HOURS
APRIL - THRU OCTOBER
EVERY 15 MINUTES

Monday - Thursday 6 a.m. - 10 p.m.

Friday 6 a.m. - Midnight

Saturday 10 a.m. - Midnight

Sunday 10 a.m. - 10 p.m.

$1.00 EACH RIDE

www.tankbus.org
859.331.8265

SOUTHBANK SHUTTLE MAJOR DESTINATIONS

CINCINNATI

Hotels:
Millennium Hotel Cincinnati - 150 W. 5th St.
Hilton Cincinnati Netherland Plaza - 35 W. 5th St.
Hyatt Regency Cincinnati - 151 W. 5th St.
Westin Hotel Cincinnati - 21 E. 5th St.
Garfield Suites Hotel - 2 Garfield Place (8th & Vine)
Cincinnatian Hotel - 601 Vine St.

Major Attractions:
Carew Tower - 441 Vine St.
Contemporary Arts Center - 44 E. 6th St.
National Underground Railroad Freedom Center - 50 E. Freedom Way
Taft Museum of Art - 316 Pike St.
Horseshoe Casino - 1000 Broadway Street

Shopping:
City Cellars - 908 Race St.
Batsakes Hat Shop - One W. 6th St.
Brooks Brothers - 505 Vine St.
Hunt Club Clothiers - 441 Vine St.
Macy's Fountain Place - 505 Vine St.
Saks Fifth Avenue - 5th & Race Sts.
Tiffany & Co. - Fountain Place
TJ Maxx - 18 W. 4th St.

Performing Arts:
Aronoff Center - Walnut St. (513) 621-ARTS www.cincinnatiarts.org/aronoff
Music Hall - 1241 Elm St.
Cincinnati Ballet (513) 621-5282 www.cincinnatiballet.com
Cincinnati Opera (888) 533-7149 www.cincinnatiopera.com
Cincinnati Symphony Orchestra (513) 381-3300 www.cincinnatisymphony.org
Taft Theatre - 317 E. 5th St. www.taftevents.com

Sports:
Cincinnati Bengals -Paul Brown Stadium
Cincinnati Reds - Great American Ball Park
Cincinnati Reds Hall of Fame & Museum - 100 Main St.
Cincinnati Cyclones - US Bank Arena

NEWPORT

Hotels:
Comfort Suites Newport - 420 Riverboat Row
Travelodge - 222 York St.

Attractions:
Newport on the Levee Entertainment and Dining Center - One Levee Way
AMC Theater - One Levee Way
World Peace Bell - 425 York St.
Star Lanes at the Levee–One Levee Way
Newport Aquarium - One Aquarium Way
BB Riverboats - Riverboat Row

NEWPORT CONTINUED

Purple People Bridge - pedestrian bridge crossing the Ohio River, east of Newport on the Levee

Arts:
Monmouth Theater - 636 Monmouth St.
Shadowbox Cabaret - One Levee Way
Stained Glass Theater - 802 York St.

Shopping:
Various Monmouth Street Shops - Monmouth St.
Bob Roncker's Running Spot - 317 Monmouth St.
Reser Bicycle Outfitters - 735 Monmouth St.

COVINGTON

Hotels:
Embassy Suites Cincinnati - RiverCenter - 10 E. RiverCenter Blvd.
Hampton Inn Cincinnati Riverfront - 200 Crescent Ave.
Courtyard by Marriott Covington - 500 W. 3rd St.
Extended Stay America - 650 W. 3rd St.
Holiday Inn West Riverfront - 600 W. 3rd St.
Radisson Cincinnati Riverfront–668 W. 5th St.
Cincinnati Marriott at RiverCenter - 10 W. RiverCenter Blvd.

Attractions:
Carrol Chimes Bell Tower - 605 Philadelphia St.
John A. Roebling Suspension Bridge - Court St. & East 2nd St.
Riverside Drive Historic District and Riverwalk Statue Tour - Riverside Drive.

Shopping:
MainStrasse Village - 6th & Main
Donna Salyers Fabulous Furs - 20 West 11th St.

Arts:
Carnegie Visual and Performing Arts Center - 1028 Scott St.
Covington Murals - floodwall at the foot of the Roebling Suspension Bridge.
Madison Theater - 730 Madison Ave.

BELLEVUE

Hotels & Bed and Breakfast:
Christopher's Bed & Breakfast - 604 Poplar Street.
Weller Haus Bed & Breakfast - 319 Poplar Street.
Holiday Inn Express - 110 Landmark Dr.

Shopping:
Fairfield Avenue - Shopping District.

GAME DAY SERVICE:
Southbank Shuttle Trolleys provide service to all home Reds and Bengals games.

REDS:
Service begins operating 2 hours before game time. In order to provide faster, more frequent service during these peak times, trolley service is often supplemented by large buses, which may travel a different route to the destination.

Great American Ball Park Southbank Shuttle Stops:
To/From Newport:
Broadway at Pete Rose Way
To/From Covington:
Walnut St. at Freedom Way (added large buses will stop on Rosa Parks, on the west side of the Freedom Center)

BENGALS:
Service begins operating 2 hours before game time. In order to provide faster, more frequent service during these peak times, trolley service is often supplemented by large buses, which may travel a different route to the destination.

Paul Brown Stadium Stops:
To/From Newport:
Rosa Parks on the west side of the Freedom Center (added large buses will stop in the Riverfront Transit Center).
To/From Covington:
Walnut St. at Freedom Way (added large buses will stop in the Riverfront Transit Center).

SOUTHBANK SHUTTLE TROLLEY FARES:

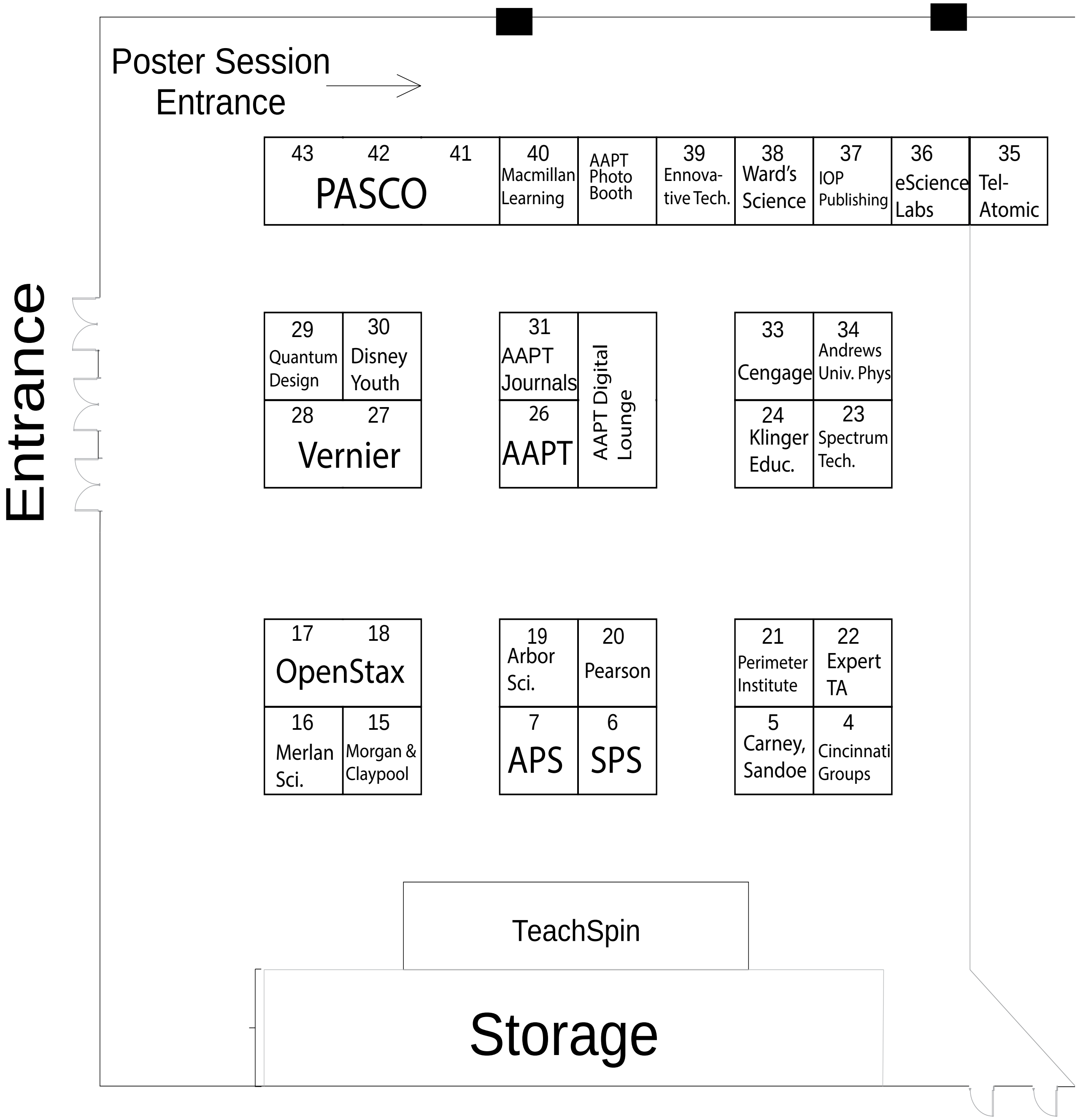
Cash Fare	$1.00
Game Day Pass	$2.00
30 Day Southbank Shuttle Pass	$44.00
Senior/Disabled Reduced Fare	$0.75
Senior/Disabled Southbank monthly sticker	$25.00

A convention pass is available for more information call 859-331-8265.

TANK
TRANSIT AUTHORITY OF NORTHERN KENTUCKY

NEED MORE INFORMATION? CALL TANK AT 859-331-TANK OR VISIT TANKBUS.ORG. THE EASIEST FASTEST WAY TO GET THERE.

Exhibit Hall
Event Center I



Download Your Mobile App Now!

Download Steps:

1. Download the app by going to https://crowd.cc/s/Rfdy, or search the “Apple” or “Google Play” stores for AAPT, American Association of Physics Teachers, SM17, 2017 AAPT Summer Meeting.

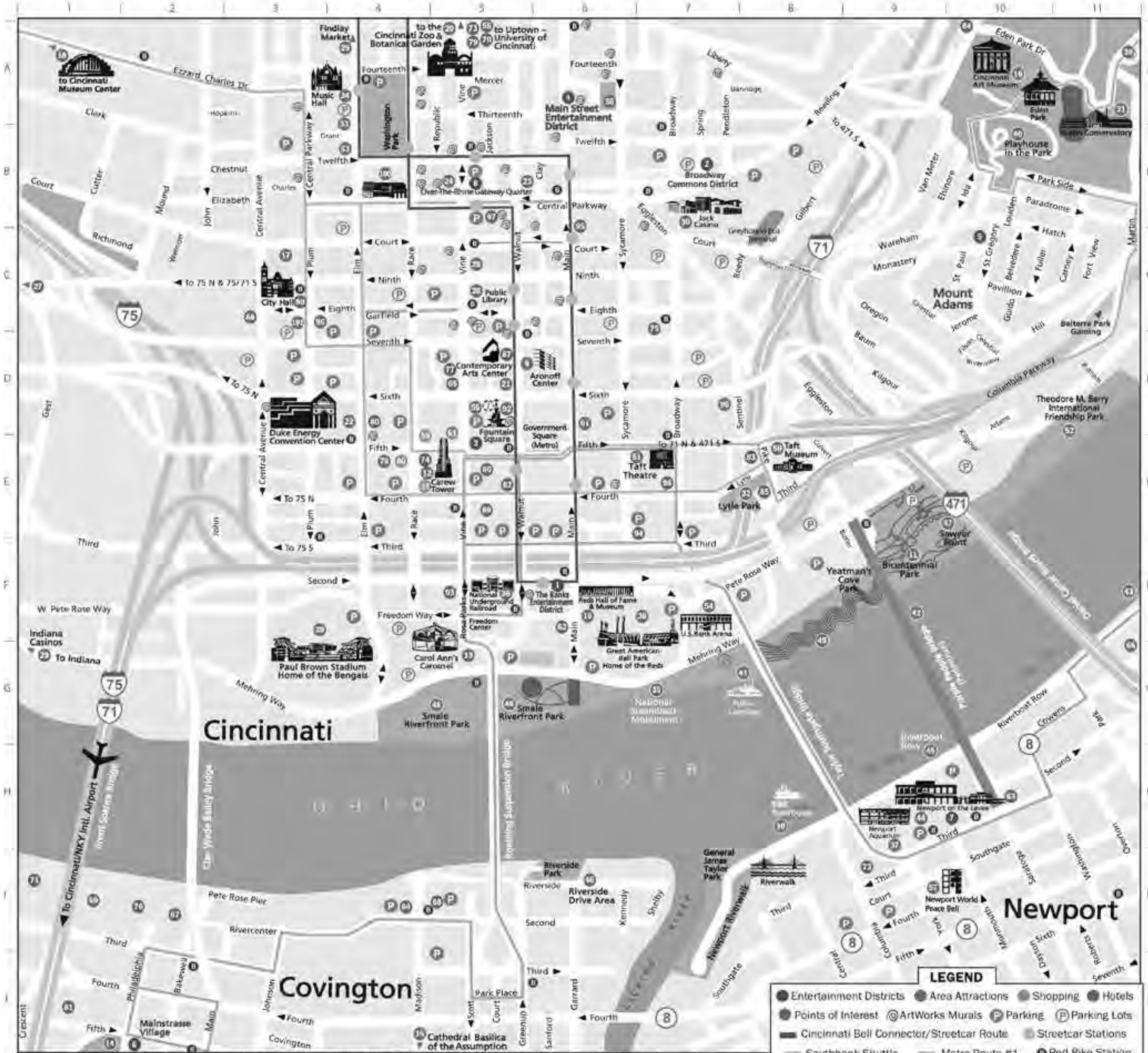
2. Open the app and tap on 2017 AAPT Summer Meeting (SM17).

CrowdCompass by Cvent

CINCINNATIUSA CONVENTION & VISITORS BUREAU

CincyUSA.com

What to do in Downtown Cincinnati and Northern Kentucky



Map provided by Cincinnati USA Convention & Visitors Bureau, 525 Vine St., Suite 1200, Cincinnati, OH 45202 www.CincyUSA.com

Locations on grid listed in ( )

Entertainment Districts

1. The Banks (F-6)
2. Broadway Commons (B-7)
3. Fountain Square (D,E-5)
4. Main Street (A,B-6)
5. Mount Adams (B,C-10)
6. Mainstrasse Village (J-2)
7. Newport on the Levee (H-9,10)
8. Over-The-Rhine Gateway Quarter (A,B-4,5,6)

Area Attractions

9. Aronoff Center for the Arts (D-6)
10. BB Riverboats Inc. (H-8)
11. Bicentennial Park (F-9)
12. Carew Tower Complex Observation Deck (E-5)
13. Carol Ann's Carousel/Anderson Pavilion (G-5)
14. Carroll Chimes Bell Tower (J-1)
15. Cathedral Basilica of the Assumption (J-5)
16. Cincinnati Art Museum (A-10)
17. Cincinnati Fire Museum (C-3)
18. Cincinnati Museum Center at Union Terminal (A-1)
    Duke Energy Children's Museum,
    Cincinnati History Museum,
    Museum of Natural History and Science,
    Robert D. Lindner Family OMNIMAX Theatre,
    Cincinnati Historical Society Library
19. Cincinnati Reds Hall of Fame and Museum (F-6)
20. Cincinnati Zoo & Botanical Garden (A-5) (See other side)
21. Contemporary Art Center (D-5)
22. Duke Energy Convention Center (D-3,4)
23. Emery Auditorium Theatre (B-5)
24. Ensemble Theatre of Cincinnati (B-5)
25. Findlay Market (A-4)
26. Great American Ball Park (F-7)
27. The Greater Cincinnati Police Historical Society Museum (C-1)
28. Hamilton County Public Library (C-5)
29. Indiana Casinos (See other side) (G-1)
30. Jack Casino (B-7)
31. Krohn Conservatory (A-11)
32. Lytle Park (E-8)
33. Memorial Hall (B-3)
34. Music Hall (A-3)
35. National Steamboat Monument (G-7)
36. National Underground Railroad Freedom Center (F-5)
37. Newport Aquarium (H-9)
38. Overlook Park (A-11)
39. Paul Brown Stadium (F,G-3)
40. Playhouse in the Park (B-10)
41. Public Landing (G-7)
42. Purple People Bridge (H-9)
43. Queen City Riverboats (F-11)
44. Ride the Ducks (H-9)
45. Riverboat Row (H-9)
46. Riverside Drive Area (I-6)
47. Sawyer Point (E-9)
48. Smale Riverfront Park (G-5)
49. Serpentine Wall (F-8)
50. Taft Museum of Art (E-8)
51. Taft Theatre (E-7)
52. Theodore M. Berry International Friendship Park (D-10,11)
53. The Transept (B-4)
54. U.S. Bank Arena (F-7)
55. Uptown – University of Cincinnati (A-5) (See other side)
56. Visitors Center (D-5)
57. World Peace Bell (I-9)
58. Ziegler Park (A-6)

Shopping

12. Carew Tower Complex/Mabley Place (E-5)
59. Macy's (E-5)
60. Saks Fifth Avenue (E-4)
61. Tiffany & Co. (E-5)

Hotels

62. AC Hotel Cincinnati at the Banks (F-6)
63. Aloft Newport-Cincinnati (H-10)
64. Cincinnati Marriott at RiverCenter (I-4)
65. Cincinnatian Hotel (D-5)
66. Comfort Suites Newport (G-11)
67. Courtyard by Marriott Covington (I-2)
68. Embassy Suites at RiverCenter (I-5)
69. Extended Stay America – Covington (I-1)
70. Fairfield Inn & Suites Cincinnati/Uptown (See other side) (A-5)
71. Hampton Inn Cincinnati Riverfront (I-1)
72. Hampton Inn & Suites Newport/Cincinnati (I-9)
73. Hampton Inn & Suites Uptown (See other side) (A-5)
74. Hilton Cincinnati Netherland Plaza (E-4)
75. Holiday Inn & Suites Downtown Cincinnati (C-7)
76. Holiday Inn Cincinnati Riverfront (I-2)
77. Homewood Suites & Hampton Inn & Suites (D-5)
78. Hyatt Regency Cincinnati (E-4)
79. Marriott Kingsgate Conference Hotel (A-5) (See other side)
80. Millennium Hotel Cincinnati (D-4)
81. Radisson Hotel Cincinnati Riverfront (J-1)
82. Renaissance Cincinnati Downtown (E-5)
83. Residence Inn Downtown (E-8)
84. SpringHill Suites (A-10)
85. The Lytle Park Hotel, Marriott Autograph Collection (E-8)
86. Westin Hotel Cincinnati (E-5)
87. 21c Museum Hotel (D-5)

Points of Interest

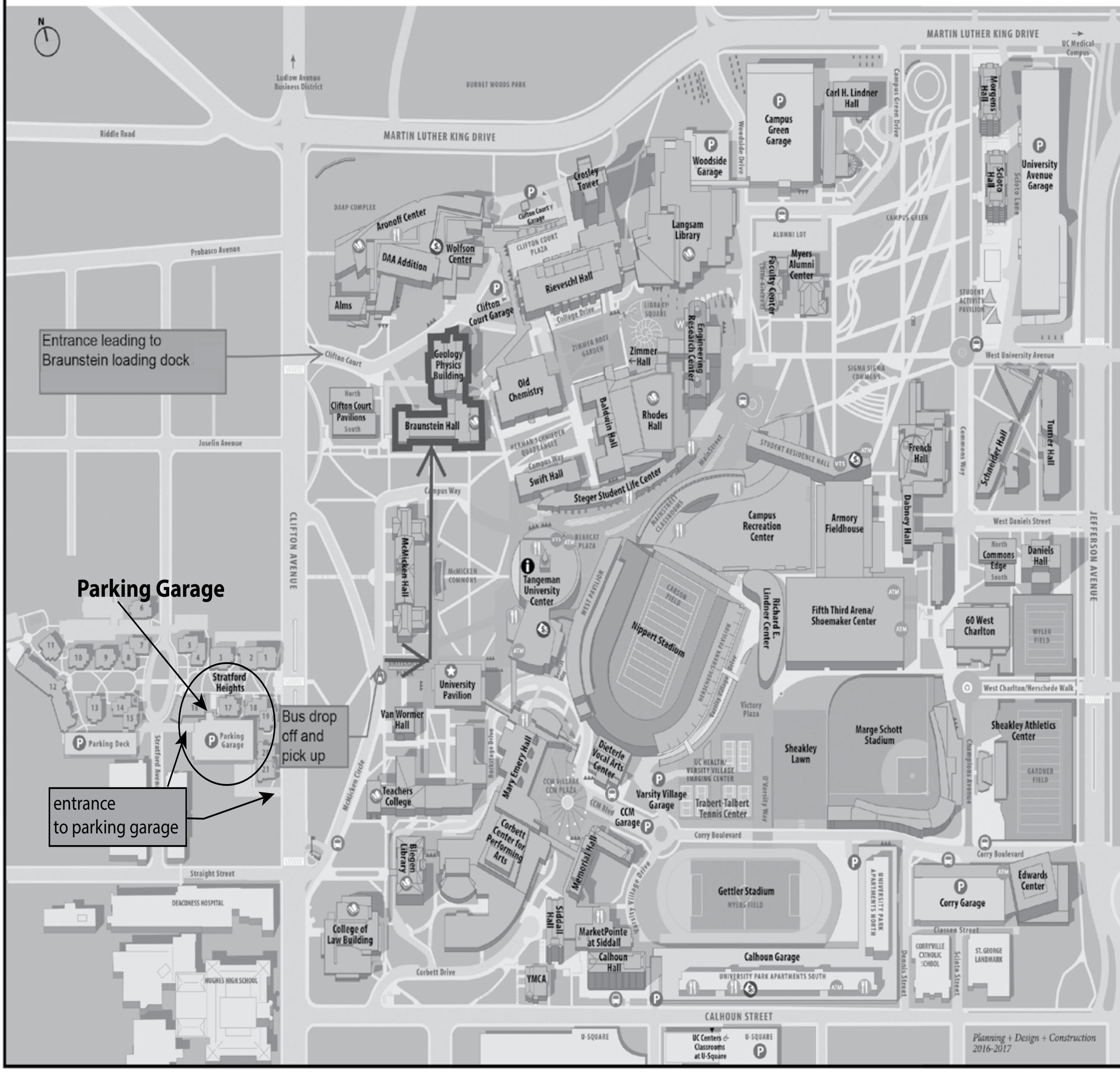
12. Carew Tower Complex (E-5) Observation Deck/Mabley Place
88. Centennial Buildings 1, 2 & 3 (C-3)
89. Cincinnati USA Regional Chamber (E-5)
90. City Hall (C-3)
91. Federal Building (D-6)
92. Fifth Third Building (D-5)
93. GE Building (F-5)
94. Great American Tower at Queen City Square (E-7)
95. Hamilton County Courthouse (B-6)
96. Isaac M. Wise Temple (C-3)
97. Kroger Building (B-5)
98. Masonic Center (E-7)
99. Procter & Gamble Headquarters (D-7)
100. SCPA (School for Creative and Performing Arts) (B-4)
101. St. Peter in Chains Cathedral (C-3)

Cincinnati USA
Visitor Center
Stop by our Visitor Center on Fountain Square for up-to-date information on Cincinnati. Hours are online at: www.cincyusa.com/visitors

DELTA
Official Airline of the Cincinnati USA CVB


Cincinnati USA Regional Map
Legend
Hotels
Area Attractions
Shopping
Universities/Colleges
Exit #
Red Bike
Bike/Hike Trails
CINCINNATI
See Reverse for Detail of Downtown
COVINGTON
NEWPORT
BELLEVUE
FT. THOMAS
FT. WRIGHT
FT. MITCHELL
FLORENCE
HEBRON
CINCINNATI/ NORTHERN KENTUCKY INTERNATIONAL AIRPORT
LUNKEN AIRPORT
UNIVERSITY OF CINCINNATI
XAVIER UNIVERSITY
CINCINNATI STATE
NORTHERN KENTUCKY UNIVERSITY
THOMAS MORE COLLEGE
COLLEGE OF MOUNT ST. JOSEPH
To MIAMI UNIVERSITY
WEST CHESTER
SHARONVILLE
BLUE ASH
MONTGOMERY
KENWOOD
INDIAN HILL
MILFORD
MADEIRA
NEWTOWN
WITHAMSVILLE
DEER PARK
READING
HYDE PARK
ST. BERNARD
FAIRFIELD
SPRINGDALE
WYOMING
FOREST PARK
BRENTWOOD
MT. HEALTHY
NORTH COLLEGE HILL
HAMILTON
BEVIS
GROESBECK
WHITE OAK
CHEVIOT
DELHI
BRIDGETOWN
ADDYSTON
NORTH BEND
CLEVES
MIAMITOWN
HARRISON
MIAMI WHITEWATER FOREST
MITCHELL MEMORIAL FOREST
SHAWNEE LOOKOUT PARK
MT. AIRY FOREST
WINTON WOODS
DEVOU PARK
EDEN PARK
OHIO
KENTUCKY
INDIANA
Ronald Reagan Hwy
Reading Rd
Hamilton Ave
Colerain Ave
Winton Rd
Montgomery Rd
Glenway Ave
Harrison Ave
Ohio River
Little Miami River
Great Miami River
Whitewater River
© 2016 GC Cincy

University of Cincinnati
Uptown West Campus Map




We'll See You in San Diego in Winter 2018!
AAPT Winter Meeting
January 6-9, 2018


. . . and We'll See You in Washington, D.C. in Summer 2018!
AAPT Summer Meeting
July 28-August 1, 2018

USER-FRIENDLY WHERE
STUDENTS NEED IT NEW
TOOLS TO ASSIST AND INS
STUDENTS CHOOSE WHIC
IMMEDIATE FEEDBACK
CHOOSE WHICH COMPONE
TO USE MORE PRACTICE
REINFORCE WHAT IS TAUGHT
IN THE CLASSROOM AND
PRESENTED IN THE TEXTBO
MATERIALS FOR A TIME
VARIETY OF LEARNING STYLES
AND KNOWLEDGE BASES
A RANGE OF QUESTIONS I
TERMS OF DIFFICULTY LE
ADDRESSES THE VARYIN