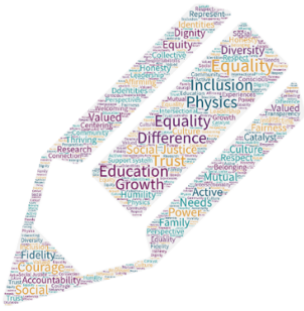
PERC 2021

Making Physics More Inclusive and Eliminating Exclusionary Practices in Physics



August 4-5, 2021 (Virtual Conference)

Thanks for joining us for PERC 2021!

The following program has all the session information to help you navigate PERC using the online underline.io platform.

Here are some links you might find useful throughout the meeting:

PER-Central Conference Website
- Schedule
- Abstracts

Link to the online conference on underline.io (login using AAPT credentials):
https://underline.io/events/166/reception

Ways to engage with the conference and other attendees:
- Twitter: @2021_perc
- Padlet discussion forums (see details on p. 3)
  - PERC-olater (general forum): https://tinyurl.com/ThePERColater
  - Bridging Session: https://tinyurl.com/PERC21BridgingSessionPadlet
  - Thursday Plenary Session: https://tinyurl.com/PERC21ThursdayPlenary
- Organizers' email address: 2021PERC@gmail.com

Making Physics More Inclusive and Eliminating Exclusionary Practices in Physics

As a gateway discipline to STEM majors and careers, physics plays a central role in deciding who does, and who doesn't, get to discover and pursue scientific careers. Technical and scientific professionals are rewarded with economic privilege and status which affords them both social and cultural power. Therefore, social justice will be realized only when the opportunity, and the choice, to excel in physics is open to all students. The culture and practices of the physics classroom reflect the culture of physics at large, which raises the question of how our professional physics communities can embrace, rather than inadvertently repel, a diverse group of academics that can help improve physics culture. To this end, the 2021 Physics Education Research Conference will focus on defining inclusive spaces and practices. Additionally, we will explore strategies for eliminating exclusionary practices in our classrooms, research spaces, and professional organizations. We call on the community to propose sessions that will drive conversations related to these initiatives throughout PERC 2021.

- What would it mean for physics and physics education research to be inclusive fields?
- How might faculty hiring and promotion practices be restructured to establish and support work in social justice as an important departmental value?
- What implicit expectations and practices in our courses result in students from majority groups and more privileged backgrounds having increased opportunities for success at the expense of marginalized populations?
- How could success in physics be redefined as an inclusive practice?

With this in mind, we seek sessions that will address these questions that challenge our communities to do better.

We approach this conference with the knowledge that historical inequities in K-20 education exist and are exacerbated by current practices, which have become even more evident in light of the current economic crisis, global pandemic, and civil unrest due to racialized violence. We share the world view that it is incumbent on us as researchers and academics to understand the landscape of those inequities in our field. We also frame this work as hopeful and optimistic, that within our communities we have the intellectual power, deep commitment and strong intention to help create a better tomorrow.

The organizers are Geraldine L. Cochran, Suzanne White Brahmia, Eric Brewe, Debbie Andres, Gina Passante, and Trevor I. Smith.

Engaging with the conference using padlets

The PERC organizers are making efforts to promote engagement with as few barriers as possible. We have decided that we will host three padlets which are discussion forums during PERC 2021. Padlets allow for people to have threaded discussions without creating an account on another platform or downloading new software.

On each of the padlets, we will be reviewing posts and removing posts that do not adhere to the AAPT Code of Conduct

There will be three padlets:
The PERC-olater (https://tinyurl.com/ThePERColater): This will be open throughout PERC and participants will be able to talk about practices, perspectives, and views as they evolve during PERC.

A Bridging Session padlet (https://tinyurl.com/PERC21BridgingSessionPadlet): Which will be open during the Wednesday August 4 Bridging Session with Karsonya 'Kaye' Wise Whitehead and Robert T. Teranishi. Participants will be able to post their responses to the speakers, and reflect on how the speakers' messages translate to action.

Thursday Plenary Session padlet (https://tinyurl.com/PERC21ThursdayPlenary): This will be open during the Thursday August 5 Plenary Session with Joshua C. Collins. Participants will be able to post their responses to the speaker, and reflect on how the speaker's messages translate to action.

At-a-glance Schedule

Wednesday, Aug 4, 2021		Page
3:00 pm EDT (12:00 pm PDT)	**Bridging Session** • **Why is Every Conversation a Conversation About Race?** *Speaker: Karsonya "Kaye" Wise Whitehead* • **Anti-Asian Racism: Implications for Research in Education** *Speaker: Robert T. Teranishi*	6 8
4:30 pm EDT (1:30 pm PDT)	**Poster Session 1** The poster session will be split into 4 rooms: A, B, C, and D. Presenters with odd-numbered posters will present during the first 20 minutes. Following a 5-minute transition period, presenters with even-numbered posters will present during the last 20 minutes.	9
5:15 pm EDT (2:15 pm PDT)	Break (30 minutes)	
5:45 pm EDT (2:45 pm PDT)	**Snack & Chat** Informal conversations hosted by volunteer participants.	14
6:45 pm EDT (3:45 pm PDT)	End of PERC Day 1	

Thursday, Aug 5, 2021		Page
11:00 am EDT (8:00 am PDT)	**Parallel Sessions Cluster 1** • **Talk Symposium** (prerecorded; live Q&A) **Reimagining physics curricula** *Moderators: D. R. Dounas-Frazer, A. V. Knaub* *Presenters: C. Alvarado, D. Marasco, C. Mathis,* • **Talk symposium** (prerecorded; live Q&A) **Considering covariational reasoning in math and physics** *Moderators: C. Zimmerman* *Presenters: C. Byerley, J. Canright, P. J. Emigh, I. W. Founds, D. A. González, M. Loverude, C. A. Manogue, H. Taylor, S. White Brahmia, C. Zimmerman* • **Roundtable Discussion** (live) **Building a network for Informal Physics Educators and Researchers** *Facilitators: C. E. Fracchiolla, M. Bennett, K. Hinko, R. Villatoro*	15
12:00 pm EDT (9:00 am PDT)	**Poster Session 2** The poster session will be split into 4 rooms: A, B, C, and D. Presenters with odd-numbered posters will present during the first 20 minutes. Following a 5-minute transition period, presenters with even-numbered posters will present during the last 20 minutes.	22
12:45 pm EDT (9:45 am PDT)	Break (15 minutes)	

1:00 pm EDT (10:00 am PDT)	**Plenary** • **Frameworks to enhance inclusion in physics education: Everyone must participate** *Speaker: Joshua C. Collins*	26
1:45 pm EDT (10:45 am PDT)	Break (15 minutes)	
2:00 pm EDT (11:00 am PDT)	**Parallel Session Cluster 2** • **Talk symposium** (live): **Equity in Precollege Physics Access, Teaching, and Learning** *Moderator: D. Rosen* *Presenters: A. M. Kelly, R. Krakehl, M. Palermo, D. M. Robbins, K. Sheppard* • **Roundtable Discussion** (live): **How can early-career members of our community shape inclusivity discourse and practice within physics?** *Facilitators: R. Henderson, W. B. Lane, T. Finzell* • **Workshop** (live): **Doing Physics Education Research Inclusively: Designing for Variation in Participants' Needs, Abilities, and Interests** *Facilitators: J. Chini, D. Oleynik, E. Scanlon*	28
3:00 pm EDT (12:00 pm PDT)	Break (30 minutes)	
3:30 pm EDT (12:30 pm PDT)	**Parallel Session Cluster 3** • **Talk symposium** (live): **Physics Public Engagement in the COVID Era: Lessons Learned and Moving Forward** *Facilitators: D. Izadi, M. Bennett, C. Fracchiolla* *Presenters: B. Stanley, J. Key, S. Schmoll, Z. Constan* • **Talk Symposium** (live): **Identifying the Resources that Support the Success of African Americans in STEM** *Moderator: G. L. Cochran* *Presenters: S. Gross, N. Howard* • **Workshop** (live): **Measuring learning assistants' Pedagogical Content Knowledge for Questioning with a written instrument** *Facilitators: J. Wang, B. Thacker, S. Hart, K. Wipfli*	33
4:30 pm EDT (1:30 pm PDT)	**Closing Session: Panel Discussion**	38
5:15 pm EDT (2:15 pm PDT)	End of PERC	

Wednesday, August 4, 3:00pm EDT (12:00pm PDT) Bridging Session

The Bridging Session will feature two speakers: Dr. Karsonya “Kaye” Wise Whitehead and Dr. Robert T. Teranishi.

Karsonya "Kaye" Wise Whitehead, Loyola University Maryland

Why Is Every Conversation a Conversation About Race?

Join the award-winning author, radio host, and three-time New York Emmy-nominated documentary filmmaker, Dr. Kaye Wise Whitehead as she connects the history of systemic racism to antiracist literature and connects what is happening across the country to what can and does happen in our cities and in our homes. Some of the topics that will be discussed include racism, whiteness and privilege, racial consciousness and awareness, and systemic inequality. Attendees will receive a three-tiered experience that discusses how racial consciousness and experience shapes self-conception, perceptions, learning, environment, and achievement. The talk will build awareness of race, create conditions that engender the study of how race interacts in the school process, and provide recommendations for participants to continue growth and development in their ability to lead in a racially equitable manner.

About Dr. Whitehead

Dr. Karsonya “Kaye” Wise Whitehead is an associate professor of communication and African and African American Studies at Loyola University Maryland and the founding director of The Karson Institute for Race, Peace & Social Justice. She is the author of four books, including *RaceBrave: new and selected works; Notes from a Colored Girl: The Civil War Pocket Diaries of Emilie Frances Davis*, which received both the 2015 Darlene Clark Hine Book Award from the Organization of American Historians and the 2014 Letitia Woods Brown Book Award from the Association of Black Women Historians; and *Letters to My Black Sons: Raising Boys in a Post-Racial America*. She is a K-12 master teacher in African American history; an award-winning curriculum writer and lesson plan developer; and an award-winning former Baltimore City middle school teacher. In 2020, Dr. Whitehead was selected by *The Daily Record* as one of Maryland’s Top 100 Women. In 2019, she received the Collegium Visionary Award from the College of Holy Cross; the Exceptional Merit in Media Award (EMMA) from the National Women’s Political Caucus; the *Baltimore Sun* named her as one of Baltimore’s 25 “Women to Watch in 2019”; and *Essence* magazine included her on the 2019 “Woke 100 List,” of “black women advocating for change.” In addition to her work as a professor, Dr. Whitehead is the host of “*Today with Dr. Kaye*” on radio station WEAA. As one of only a few daily drive-time afternoon radio shows hosted by a black woman, *Today with Dr. Kaye* received the 2020 Chesapeake Associated Press Award for Outstanding Editorial or Commentary; the 2019 Associated Press Award for Outstanding Talk Show, and the second place Award for Outstanding Editorial or Commentary. In 2020, the *Baltimore Sun* selected Dr. Kaye as the Best Radio Host. In February 2016, Dr. Whitehead received the Joan B. Kroc’s Institute for International Peace

Studies “Distinguished Alumni” Award for her work as a peace activist, scholar, filmmaker, writer, and poet. In 2014, she received the 2014 Lifetime Achievement Award from the Progressive National Baptist Convention (PNBC); was selected as one of the top 25 women professors in Maryland by Online Schools Maryland; and in 2013, received Loyola University Maryland’s Faculty Award for Excellence in Engaged Scholarship for her work documenting the stories of women who are temporarily experiencing homelessness. Dr. Whitehead also received the 2006 Gilder Lehrman Preserve America Maryland History Teacher of the Year Award (sponsored by the Gilder Lehrman Institute of American History and the Maryland State Department of Education); was one of 50 alumni to receive the Distinguished Black Alumni Award from the University of Notre Dame, Indiana (2005); and was a winner of both the Langston Hughes, David Diop, Etheridge Knight Poetry Award (1999, 2000) and the Zora Neale Hurston Creative Writing Award (1998) from the Gwendolyn Brooks Creative Writing Center at the University of Chicago. Prior to her work in academia, Dr. Whitehead was a documentary filmmaker with MetroTV, a PBS-affiliate, and a senior producer for Music Television Networks (MTV). In 2001, she directed and produced *Twin Towers: A History*, a documentary film describing the technical problems and challenges ironworkers faced in constructing the landmark buildings and recounts the daredevil stunts that the buildings attracted. The film was nominated for an Emmy in 2002—Dr. Whitehead’s third nomination. It has since become the second-largest selling film about 9/11 and airs regularly on PBS stations around the country. Dr. Whitehead writes a bi-monthly column, “Conversations with Dr. Kaye,” for the Baltimore *Afro* newspaper based upon her deep ethnographic study within the Black Butterfly neighborhoods of Baltimore City. She is also one of the most sought-after keynote speakers in the country, having given over 500 keynotes worldwide.

Robert T. Teranishi, University of California, Los Angeles

Anti-Asian Racism: Implications for Research in Education

In a recent survey, 45% of Asian American adults reported experiencing incidents ranging from verbal harassment to destruction of property to physical assaults during the COVID pandemic. These findings coincide with other data that has found that there were more than 6,600 anti-Asian racist incidents reported in the past year – a 150% increase from the prior year. While national surveys of Asian Americans can help identify broader indicators about the rise of Anti-Asian racism and discrimination, this presentation will discuss the implications for research in educational settings and the need for particular attention to marginalized and vulnerable Asian American sub-groups, Asian Americans in specific institutional settings (four-year colleges, community colleges, etc.) and research that can more directly inform the work of advocates and policymakers as they work to improve programs and services that can address these unique needs and challenges.

About Dr. Teranishi

Robert Teranishi is Professor of Social Science and Comparative Education, the Morgan and Helen Chu Endowed Chair in Asian American Studies, and director for the Institute for Immigration, Globalization, and Education at the University of California, Los Angeles. He is also a senior fellow with the Steinhardt Institute for Higher Education Policy at New York University. His research examines the causes and consequences of the stratification of college opportunities, with a particular interest on the impact of higher education practice and policy on the mobility of marginalized and vulnerable communities. Teranishi's research has been influential to federal, state, and institution policy related to college access and completion. He has testified before Congress on the Higher Education Reauthorization Act, the College Cost Reduction and Affordability Act, and the Elementary and Secondary Education Act. His research has been referenced in U.S. Supreme Court cases on school desegregation and affirmative action in college admissions. In 2011, he was appointed by Secretary of Education, Arne Duncan to the U.S. Department of Education's Equity and Excellence Commission. In 2015, he was appointed by President Barack Obama to serve as a member of the National Board for the Institute for Education Sciences. He has also served as a strategic planning and restructuring consultant for the Ford Foundation. Teranishi has received national awards from the National Institute for the Study of Transfers, the National Association of Student Affairs Professionals, and the Association for the Study of Higher Education. He has received the Martin Luther King, Jr. Faculty Award and the Daniel E. Griffiths Award at NYU and the Robert M. Stevenson Award at UCLA. Teranishi has also been ranked among the most influential academics in the field of education by *Education Weekly* and was named one of the nation's top "up-and-coming" leaders by *Diverse Issues in Higher Education*. Teranishi was formally a National Institute for Mental Health postdoctoral fellow at the University of Pennsylvania's W.E.B. Du Bois Research Institute. He received his B.A. from the University of California, Santa Cruz in Sociology and his M.A. and Ph.D. from the University of California, Los Angeles in Higher Education and Organizational Change.

Wednesday, August 4, 4:30pm EDT (1:30pm PDT)
Poster Session 1

This poster session will be held in Gather.town and accessed through the underline.io webpage. Posters are divided into 4 rooms: A, B, C, and D. Presenters with odd-numbered posters will present during the first 20 minutes. Following a 5-minute transition period, presenters with even-numbered posters will present during the last 20 minutes.

Posters are all available on the underline.io website for pre-conference viewing. Each poster links to the abstract information on PER-Central.

Abraham, Yohannes Medhanie	Exploring student conceptual resources about heat and temperature	1A-24
Adams, Adrian	Investigating Students' Process of Data Cleaning	1C-21
Allen, Scott	Student perceptions of pre-assessments: "It's basically just guessing anyways"	1A-4
Ametepe, Joseph	Error propagation employed to establish error bounds in projectile motion lab	1C-16
Amin, Bahar	Reflective Journaling in the Era of COVID	1C-6
Anthony, Adam K.	Undergraduate learning assistants and the transition to online learning	1D-18
Ayouz, Mehdi	An experience-based course of quantum mechanics: Numerical experiments ranging from stepwise potentials to wave packet propagation and perturbation theory	1A-13
Bajracharya, Rabindra	Student understanding and applications of infinity in physics and mathematics	1C-22
Bauman, Lauren C	Centering physics faculty ideas about resources-oriented instruction	1A-5
Becker, Sebastian	Using mobile eye tracking to capture joint visual attention in collaborative experimentation	1C-15
Bennett, Michael	Transitioning to Online Learning in an Informal Physics Program	1B-6
Borish, Victoria	Student Engagement with Modeling in Multi-Week Student-Designed Lab Projects	1A-15
Bottomley, Ewan	Gender effects in perceived recognition as a physicist and physics identity	1D-3
Breakall, Jared B.	Faculty perceptions of grade 7-12 math and science teaching as a career: Evidence from a reduced-basis factor analysis of the PTAP.HE Instrument	1B-9
Bridges, Bill	Identifying epistemic games in faculty discussions about values in science	1C-17
Burkholder, Eric	Epistemological framing and strategy use during answer-checking	1A-7
Canright, Jared P	Developing expertlike epistemologies about physics empirical discovery using virtual reality	1A-17
Cao, Ying	Shared Resources in Student Problem-Solving of Spherical Unit Vectors	1A-26
Chastain, Raymond	Students with Disorganized Study Habits Benefit from Cognitive Prompts During Online Video Lectures	1D-24

Chen, Zhongzhou	Measuring the level of homework answer copying during COVID-19 induced remote instruction	1D-23
Chini, Jacquelyn	Explicating Universal Design for Learning-aligned instructional practices for postsecondary STEM	1D-11
Coffie, Camille	Disciplinary tensions in applying Universal Design for Learning to postsecondary STEM	1C-3
Conlin, Luke	Supporting and Studying Introductory Physics Students' Algebra Skills with Solve-It	1A-10
Crossette, Nathan	Comparing undergraduate and graduate student reasoning on a conceptual entropy questionnaire	1A-19
Cueva Vera, Pablo J	A Student-Centered Understanding of the Impacts of Environmental Inequities on Teaching and Learning during Remote Instruction	1D-2
Degtiareva, Vera	Pedagogy in practice: exploring the use of pedagogy course knowledge by learning assistants	1B-11
Doty, Constance	GTAs' Use of Pedagogical Skills during a Remote Mixed-reality Simulator Training Session	1A-16
Elhady, Yasmene Wang	Effects of facilitating collaboration in large-enrollment introductory physics courses	1D-20
Engblom, Samuel	Studying the Learning Assistant Experience at the University of Illinois Urbana-Champaign	1B-5
Erukhimova, Tatiana	Impact of informal physics programs on female university students	1D-4
Fiedler, Brett L.	Multimodality and inclusion: Educator perceptions of physics simulation auditory display	1D-7
Fracchiolla, Claudia	Computational practices in introductory science courses	1C-11
Gambrell, Justin	Identifying important computational skills in introductory physics: An interview analysis	1A-3
Gavrin, A.	Preliminary efforts to evaluate an initiative introducing computation across the undergraduate physics curriculum	1A-2
Genz, Florian	Naïve concepts of aerodynamic lift – data lessons from different (learning) cultures	1A-25
Green, Colin	Sentiment analysis of faculty responses; transition to online learning	1D-15
Hamerski, Paul C.	Dispositions and mindset in computation-integrated physics	1C-4
Hart, Reginald	Analyzing laboratory teaching practices through the lens of student ownership	1C-7
Henderson, Rachel	Developing an Instrument to Assess the Next Generation Science Standard Practice Planning and Carrying out Investigations in Preservice STEM Teachers	1B-1
House, Lindsay	Power of the people: Using citizen science to power big data astronomy	1B-10
Indukuri, Sadhana	Developing a framework to characterize the feedback that Learning Assistants give to faculty	1B-13
Jaramillo, Sara	Investigating causal inference difficulties with a simple, qualitative force-and-motion problem	1A-21

Kargal, Sejal	Reimagined Virtual Upper-Division Physics Laboratory Experiences in Response to the COVID-19 Pandemic: Findings from User Experience Testing	1D-21
Keebaugh, Christof	Student difficulties identifying diagonal operators for degenerate perturbation theory	1A-22
Kinnischtzke, Meghan	Investigating relationships between emotional states and self-efficacy, agency, and interest in introductory labs	1A-6
Kumar, Sailakshmi	Practices in an online computational class of high school teachers	1C-10
Lane, W. Brian	Comparison of student and instructor reasons for using computation	1D-22
Lassen, Ira Ché	Student ownership and understanding of multi-week final projects	1C-12
Lindell, Rebecca	Not Quite Face to Face: Conducting Qualitative Phenomenographic Interviews Virtually	1C-2
Logan, Savannah	A comparison of student perceptions of the teaching profession at minority-serving and non-minority-serving institutions	1B-2
Longo, Francesco	Monitoring the wave phenomena learning process through Bayesian updating activities	1B-19
Lopes, Jomar	Exploring Experiences, Benefits, Challenges, and Dynamics in a Developing Learning Assistant Program	1B-15
Mackessy, Grace	Comparing student conceptions and construction of while loops in modeling motion	1C-19
Madsen, Adrian M.	Using the PhysPort Data Explorer to analyze research-based assessment results	1C-23
Marshman, Emily	Student difficulties with the basics for a system of non-interacting identical particles	1A-23
Mason, Andrew J.	Attitudes toward Physics Problem Solving: In-Person vs. Hybrid Instruction"	1D-17
Mathis, Clausell	The Role of Physics Culture in Shaping In-Service Physics Teacher Identities and Framings of Equity: Two Case Studies	1D-6
May, Jason M	Students' productive strategies when generating graphical representations: An undergraduate laboratory case study	1C-14
McInerny, Alistair	Examining the efficacy of a professional development assessment tool	1C-1
Mellen, Jillian	Predictors of faculty sentiment on their transition to online teaching	1D-12
Meyer, Josephine	Investigating students' strategies for interpreting quantum states in an upper-division quantum computing course	1C-18
Moore, Christopher	Modification and Validation of the Teaching Practices Inventory for Online Courses	1A-1
Murray, Jeffrey W.	Analyzing and Interpreting Data in Physics Class for Future Elementary Teachers	1B-12
Noga, Adi	Teachers' awareness of aspects of experimental design: the case of multimeters	1B-18

Ortega, Lizette	An investigation of how instructors choose to implement the Learning Assistant (LA) pedagogy course and their motivations	1B-16
Osborn, Timothy Kyle	Inequity in North Carolina High School Physics Outcomes: Gender and Race	1D-9
Pacheco, Daniel	Impacts of modeling physics-inspired pedagogical practices and career development activities on student learning and identity growth in modern physics	1A-9
Patterson, Zac	Ontological barriers to contemporary physics instruction in secondary classroom	1A-8
Perry, Jonathan	Comparing the impact of informal physics program on undergraduate versus graduate student facilitators	1B-4
Porter, Christopher D	Tracking Graduate Admissions During COVID-19: Year One	1D-14
Randall, Allyson	Relations between Teacher, Student, and Content in Physics-based Engineering Activities	1A-12
Robertson, Trevor	Horizon Content Knowledge and the Interdisciplinary Horizon in Physics Education Research	1B-7
Romick, Cora	Personas of STEM students completing online instructions during the COVID-19 pandemic	1D-16
Roundy, David	The new Paradigms in Physics Curriculum Website	1A-11
Rudnick, Phoebe	Exploring the Goals and Objectives of Informal Educators	1B-3
Ruggieri, Charles	Addressing Barriers in Introductory Physics: Multiple Modes of Engagement and Feedback	1D-1
Salty, Kaleigh	Exploring learner variability and disability identity in STEM students with ADHD	1D-8
Scanlon, Erin	Students' use of disability accommodations in emergency remote teaching	1D-5
Shafer, Devyn	Expert-Novice Teacher Interactions in a Professional Development Partnership Program	1B-14
Sikorski, Tiffany-Rose	Prioritizing student coherence seeking on concept questions	1A-14
Sirnoorkar, Amogh	A methodology for identifying task features that facilitate sensemaking	1A-20
Smith, Raymond	Interactions between physics and design students: developing a community of practice in a virtual, informal space	1A-18
Solorio, Christian	How Students Organize Quantum Concepts and Representations: A Card Sorting Task	1C-20
Trucks, Jesica L	Developing a tool to measure interest in audiences of a virtual planetarium show	1B-8
Urquhart, Mary	Design of a scaffolded interactive for integration of computational thinking into introductory physics	1C-5
Verostek, Michael	Time to PhD completion is no different between men and women despite score gap on physics GRE	1D-10
Wan, Tong	Investigating student ability to draw conclusions from measurement data	1C-13

Weber, Jannis	Conceptual understanding of Newtonian dynamics in a comparative study of computational modeling and video motion analysis	1B-20
Xie, Rachel	Cultural Capitals Expressed through Reflective Journaling in Introductory Physics & Astronomy Labs	1C-8
Young, Tamara G.	Middle grade students reasoning about temporary magnetism	1B-17
Zich, Raymond	Incorporating computational activities in a general education astronomy course	1C-9
Zipperer, Emma	Online teaching-learning in STEM SCALE-UP classrooms during the COVID-19 pandemic: feedback from students	1D-19
Zohrabi Alaee, Dina	A case study approach to understanding a remote undergraduate research program	1D-13

Wednesday, August 4, 5:45pm EDT (2:45pm PDT) Snack & Chat

For the PERC 2021, in place of the Dine and Discuss that are common during an in-person meeting, we are continuing the practice of Snack & Chat gatherings. These are semiformal/informal discussions around a specific topic of the organizers' choosing. Please see the following site for details of available topics.

Details of the Snack & Chat options:

https://tinyurl.com/SnackChatPERC21

Thursday, August 5, 11:00am EDT (8:00am PDT)
Parallel Session Cluster 1

Building a network for Informal Physics Educators and Researchers

(Roundtable Discussion)

Claudia Elena Fracchiolla, University College Dublin and American Physical Society
Co-authors: Michael Bennett, University of Colorado Boulder
Kathleen Hinko, Michigan State University
Rose Villatoro, American Physical Society

In this round table discussion, we propose a pathway toward constructing a productive community of practice around public engagement that connects educators and researchers. The majority of informal physics educators (physicists and physics students) facilitating informal physics programs and activities lack formal training and knowledge of effective practices on public engagement, including the development of cultural competencies. Furthermore, informal physics educators are often disconnected from the vast swath of resources created by the broader informal STEM community. As more departments, institutions, and funding opportunities are using public engagement to attract students and meet diversity goals, it is becoming necessary to build structures and an associated network informed by responsible design and research principles to support this community of practice and its efforts. In this session, we want to discuss the immediate and long-term needs, and what structures and resources we can build to support community engagement and development.

Considering covariational reasoning in math and physics
(Talk Symposium: prerecorded presentations)

Charlotte Zimmerman, University of Washington

Characterizing change is at the heart of physics. Mathematics and physics education researchers grapple with how change is conceptualized and quantified. The ways in which students make sense of how two quantities are related -- how changes in one quantity affect changes in another -- have been an integral part of physics education research on scaling, proportional reasoning, and modeling. In mathematics education research, this is called covariational reasoning, and is often described as a central skill for precalculus and calculus curriculum. These courses are typically considered pre- or co-requisites for introductory physics courses, suggesting that students may be assumed to have strong, reliable covariational reasoning skills as an outcome of their math courses. Recent work in both physics and mathematics education indicates that covariational reasoning involves high levels of sophisticated thinking, and by considering it prerequisite we may unintentionally enforce a barrier for students coming into physics. As mathematics education is highly variable across U.S. high schools, this prerequisite thinking may also disproportionately affect students from low socioeconomic backgrounds. In this parallel session, we bring together physics and mathematics education experts to explore the overlap of covariational reasoning in our disciplines. We will consider the ways that we collectively ask students to reason about related quantities and discuss modes of student reasoning about change and rates of change. In addition, as a mechanism for broadening access and differentiating instruction in our courses, we aim to foster a discussion about supporting instructors (and students) to shift the narrative towards framing covariational reasoning as an emerging and developing skill during college physics and mathematics courses. The session will begin with talks from each of the researchers, and conclude with time for a larger discussion and questions for speakers.

Assessing Covariational Reasoning in College Calculus and Physics Courses: The Use of Graphs

Primary Contact: Cameron Byerley, University of Georgia

Both calculus and physics were invented to describe how quantities change together. For example, calculus can help us specify precisely the difference between the rate of change of a quadratic function and the rate of change of an exponential function. College instructors use many methods to help students represent relationships between quantities and to help students make sense of new ideas such as rate of change functions (derivatives).

Graphs are often used in calculus to convey new concepts and covariational relationships to students. For example, teachers often use graphical representations to convey why derivatives find the rate of change of one quantity with respect to another. Additionally, graphs are often part of assessments in calculus and physics class. For example, given a graph that shows the amount of a quantity at any moment in time, can the students produce a graph that shows the rate of change of that quantity at any moment in time. In both of these teaching situations-using students' graphs to assess their understanding and using teachers graphs to convey new concepts-there is often an implicit assumption that students understand graphs as representing and emergent trace of the covariation of two quantities (Moore et. al., 2017).

If students do not understand a graph as representing covariation of two quantities, and the teacher primarily explains the meaning of a derivative graphically, the students are not likely to learn the meaning for derivative the teacher intended to convey. Our research team has also found that calculus students are often able to describe covariational relationships using words and gestures that they are not able to correctly represent graphically on assessments of covariational reasoning (Tyburski et. al., 2021; Drimalla et. al., 2020). This talk will discuss the importance of helping calculus and physics students' understand graphs as covariational relationships between two quantities.

Connecting mathematics education and climate change education through covariational reasoning

Primary Contact: Darío A. González, Universidad de Chile

The present study examined the covariational reasoning of three preservice mathematics teachers (PSTs) as they make sense of a simple model to introduce climate change. The PSTs worked on a mathematical task that required PSTs to activate their covariational reasoning abilities in order to explore two key notions related to climate change: (i) the balance of energy between the components of the climate system (Sun, surface, and atmosphere), and (ii) the link between carbon dioxide (CO2) pollution and global warming. The PSTs completed the task during an individual, task-based interview of approximately 60 minutes.

The analysis revealed that, in order to develop a operative understanding the climate system model, the PSTs' covariational reasoning must support, at a minimum, the ability to: (i) understand how the balance between the energy inflow into and the energy outflow from the climate system regulates the variation of the plante's mean surface temperature over time (dynamic relationships), and (ii) conceptualize the energy exchange between the surface and the atmosphere interms of two energy flows changing in tandem and obeying a circular relationship as time elapses (feedback loop). The analysis also revealed that the differences in the PSTs' covariational reasoning abilities coincided with two ways of thinking about the link between CO2 pollution and global warming: a productive way of thinking that had the potential of making visible the role of human activities in driving global climate change, and a less productive way that had the potential of promoting misconceptions about regarding that environmental challenge.

The study's results show that PSTs can engage in covariational reasoning while they learn about climate change and that covariational reasoning (and in general mathematics education) can have a role in promoting climate change education.

How Students Reason about Changes when Finding Partial Derivatives

Primary Contact: Paul J. Emigh, Oregon State University
Co-authors: Ian W. Founds & Corinne A. Manogue

Partial derivatives are among the many mathematical tools used throughout physics to help describe the physical world. We have been investigating how students are able to determine and interpret partial derivatives both symbolically and from contour graphs with mathematical, electrostatic, and thermodynamic contexts. While many students had strong procedural abilities for calculating derivatives, most did not strongly link this process (of finding a partial derivative) with the idea of "holding a variable constant," especially when dealing with a thermodynamics context. We found this to be true regardless of the representation in which students were asked to work. These results suggest a deeper theoretical framework is needed for understanding how students think about partial derivatives.

Prompting sense-making with bidirectional reasoning using a convention-breaking representation in kinematics

Primary Contact: Michael Loverude, California State University Fullerton
Co-authors: Henry Taylor

The function concept is central to college math instruction. Introductory physics courses approach many of the same topics and use what seem to be the same mathematical ideas, but the level of emphasis on the function concept in most introductory physics courses is minimal. We describe efforts to examine student physics learning using ideas adopted from the Research in Undergraduate Mathematics Education (RUME) community, including student understanding of functions as well as covariation [Carlson et al 2002]. In particular we highlight work inspired by the RUME literature [Moore et al 2014, 2015] in which student sense-making is prompted by tasks that break typical representational conventions. We will describe student responses to tasks posed in interviews in which we used comparison tasks drawn from the existing PER and RUME literature as well as a novel, convention-breaking task intended to probe an aspect of covariation known as bidirectionality [Thompson 1996, Moore 2015].

Supported in part by NSF grants PHY#1406035 and PHY#1912660 as well as the Black Family Foundation.

Emerging covariational reasoning student resources in physics lab courses

Primary Contact: Charlotte Zimmerman, University of Washington
Co-authors: Jared Canright, University of Washington
Suzanne White Brahmia, University of Washington

Students and experts engage in a plethora of sophisticated ways of thinking during modeling tasks, blending between mathematical and physical reasoning. This integrated way of reasoning about quantities and how they are related is ubiquitous to "thinking like a physicist." One facet of this process is covariational reasoning -- reasoning about how changes in one quantity relate to changes in another quantity. In laboratory courses that engage students in experimental design, students commonly use covariational reasoning as they model changing quantities and the relationships between them. However, those without strong mathematical reasoning skills may unintentionally be perceived as also

having less nuanced physics reasoning skills. To investigate the multifaceted ways students model in physics lab courses, we examined student discussions during remote, student-designed labs in which students interact with physical, but fictitious, matter in a virtual reality (VR) simulation. The VR environment allows for students to observe and measure novel situations for which the "answer," in this case a mathematical model about the particles' behavior, is not known. Using a conceptual blend analysis, we examine two lab groups that take different approaches to the task, despite beginning with the same observations and reporting on the same final model. One group demonstrates expert-like mathematical reasoning that is typically rewarded in physics courses, while the other engages in early signs of expert-like physics reasoning. Our analysis suggests that there are productive ideas emerging in both groups, and that of the less mathematically rigorous may be going unnoticed. We suggest that characterizing these features of physics covariational reasoning may provide an opportunity to move beyond data analysis techniques in lab courses towards incorporating more physics expert-like techniques. In doing so, instructors may recognize hidden strengths that may otherwise go undetected.

Reimagining physics curricula

(Talk Symposium: prerecorded presentations)

Dimitri R. Dounas-Frazer, Western Washington University; Alexis V. Knaub, AAPT

This session features physics educators and education researchers who interweave sociopolitical and cultural considerations into physics curricula with a focus on student learning. Our goals are to elevate creative work that challenges traditional conceptions of what physics education is or can be, and to inspire innovation in education research, curriculum development, and instruction. In addition, we aim to identify cross-cutting theoretical perspectives that link such work. If the PERC 2021 is virtual, we aspire to dedicate time for participants to (re)engage with speakers' recorded videos if needed, facilitate a fishbowl discussion during which speakers engage with each other's work, and create space for participants to follow up with one or more speakers of their choice.

A Look at Physics Teachers Searching for Cultural Relevance

Primary Contact: Clausell Mathis, University of Washington

Dr. Clausell Mathis will discuss research on strategies and methods that physics teachers have used to become culturally relevant educators. In particular, Clausell will describe a previous study he did with a female physics instructor who attempted to incorporate culturally relevant pedagogy features, along with his current research in assisting physics teachers to be more equitable in their instruction. Findings from his work show that teachers show the strongest indicators of culturally relevant pedagogy through their willingness to address sensitive topics, consistent encouragement of students toward academic excellence, and the ability to adapt the curriculum to students' strengths. However, there remain challenges that physics teachers have in actualizing culturally relevant pedagogy. Findings from Dr. Mathis's research give implications for physics faculty who wish to use culturally relevant pedagogy in their instruction. He will also discuss the challenges and affordances that may occur when making pedagogical changes that support culturally relevant instruction.

Empowering future teachers to recognize and transform scientific practices

Primary Contact: Carolina Alvarado, California State University, Chico

Physics, as a field, continues to be a predominantly white space, and there is limited access to physics in high schools that serve predominantly students of color. In a physics course serving future elementary and secondary science teachers, how do we introduce students to the scientific practices while our goal is to transform them? I present how students engage in recurrent discussion on power dynamics disrupting harmful practices in our physics environment. The conversations uplift voices that have been living with this knowledge without many venues in science to discuss it and force groups who have never had to address it to do so. We analyze how colorblindness can still be embedded in the discussion while having "good intentions". This is a particularly relevant discussion to share since, for many youth, K-9 teachers might be the first and last contact with physics.

Fritz Haber: Talking about more than physics in physics class

Primary Contact: David Marasco, Foothill College

In my general education class that centers on Albert Einstein, I feature a segment on his friend and contemporary Fritz Haber. Haber is a complex figure in history; he both figured out how to synthesize fertilizer, making food cheap for the masses, and he was the father of chemical warfare. His story allows for a deep exploration of how science and society overlap and interact. With fertilizer, there are issues ranging from the depletion of natural resources to actions by organized labor to geopolitics. The transition to warfare takes a path through the Oklahoma City bombing and the Tulsa Massacre. Haber's role in chemical warfare raises the topic of technology and the military. Clara Immerwahr, who was married to Haber, was one of the first STEM PhDs in Germany, and as a Jew, Haber was persecuted under Hitler. I will discuss not only the topics covered, but also the framing of the material, and the accompanying student project.

Thursday, August 5, 12:00pm EDT (9:00am PDT)
Poster Session 2

This poster session will be held in Gather.town and accessed through the underline.io webpage. Posters are divided into 4 rooms: A, B, C, and D. Presenters with odd-numbered posters will present during the first 20 minutes. Following a 5-minute transition period, presenters with even-numbered posters will present during the last 20 minutes.

Posters are all available on the underline.io website for pre-conference viewing. Each poster links to the abstract information on PER-Central.

Abdurrahman, Fatima	Objectivity, culturelessness, and apoliticism: how cultural beliefs prevent the advancement of equity in astronomy graduate programs	2D-12
Becker, Dr. Sebastian	Gaze pattern analysis to reveal student difficulties in interpreting kinematic graphs	2A-22
Bergeron, Paul	Towards an analytic framework for characterizing student use of models	2A-14
Beverly, Nancy	Variations on Effort Grading in Introductory Physics for Life Science – Lessons Learned	2D-4
Bloodworth, Dylan	Investigating the connection between course grades and student participation in research-based assessments	2D-3
Bradbury, Forrest R	Using the Assessment Rubric for Physics Inquiry for open inquiries in a multidisciplinary lab course	2C-4
Bralin, Amir	Undergraduate students' and graduate teaching assistants' perceptions of engineering design in introductory physics	2A-5
Brundage, Mary Jane	Evolution in student conceptual understanding of electricity and magnetism	2C-20
Buncher, John B.	Bias on the Force Concept Inventory across the intersection of gender and race	2C-2
Byrd, John	Characterizing Learning Gains in a Two-Year College Embedded Research Course	2A-1
Campbell, Jennifer	Understanding the Efficacy of Machine Learning for Coding Practices	2C-14
Campos, Esmeralda	Comparing students' understanding of Gauss's and Ampere's laws with field sources in square-like symmetries	2A-25
Cardona, Pedro	Access to opportunities affects physics majors interest and choice of methods specialization	2B-17
Cervantes, Bianca	An Overview of Quantum Information Science Courses at US Institutions	2B-7
Chen, Eliran	Combining expert- and cluster-analysis for Group-level personalization	2C-17
Corsiglia, Giaco	Online Tutorials for Middle-Division Quantum with Adaptive Guidance	2A-7
Cwik, Sonja	Women have lower physics self-efficacy controlling for grade even in courses in which they outnumber men	2D-14
Doucette, Danny	Challenges of building an inclusive community of learners in the physics lab	2B-4

Li, Yangqiuting	How learning environment predicts students' physics grades and motivational beliefs in introductory physics courses	2B-15
Liu, Dan	A study of undergraduates' understanding of vector - decomposition of forces on inclined planes	2A-16
Liu, Jerry	Scalable, pencil-and-paper homework with metacognitive student outcomes and minimal instructor time	2A-10
Malespina, Alysa	To whom do students believe a growth mindset applies?	2A-2
Maries, Alexandru	A cross-sectional analysis of physics self-efficacy, perceived recognition, interest and identity of physics majors	2B-3
Mays, Mikayla	Supporting student construction of alternative lines of reasoning	2A-13
McDermott, Liam	What students gain outside the classroom: Using Social Network Analysis to understand the role of affinity-based professional groups	2D-20
Munsell, Jeremy	Using natural language processing to predict student problem solving performance	2C-19
Myers, Carissa	Identifying Threats and Supports to Self-Efficacy Using Mixed Methods Research	2B-13
Nissen, Jayson	Societal Educational Debts Due to Racism and Sexism in Calculus-based Electricity and Magnetism Courses	2D-6
O'Donnell, Christine	Culturally Responsive Astronomy Education: Using a Critical Lens to Promote Equity and Social Justice	2D-15
Oleynik, Daniel	Examining physicists' perspectives of career viability and knowledge of impairment	2D-8
Oliver, Kristin	Understanding combinatorics challenges in an upper-division thermodynamics course	2A-15
Olsen, Joe	Characterizing social behavior patterns in teaching assistant interactions with students	2B-18
Ota, Shuya	New observable to identify key answer options in Brief Electricity and Magnetism Assessment for improving students' learning	2C-10
Ozmetin, Asim	Does Instructor Gender Matter for Student Performance in Introductory Physics?	2C-15
Paulger, William	Themes in student self-assessments of attitudinal development in the CLASS	2C-16
Pawlak, Alanna	Fostering departmental change through collaborative work: an analysis of two approaches and their implications	2B-6
Phillips, Anna McLean	A critical examination of "expert-like" in physics education research	2B-2
Poteet, William	Evaluating the Effectiveness of Peer Review in Introductory Physics Labs	2D-1
Quan, Gina	Unpacking Challenges in Student-Faculty Partnerships on Departmental Action Teams	2B-5
Rainey, Katherine D.	Faculty Perceptions of Three-Dimensional Learning Performances Addressing Thermal Physics	2C-12
Riihiluoma, William D.	Using network analysis techniques to probe student connections between Dirac notation and wave function expressions	2C-18
Rodriguez, Miguel	Microaggressions and Isolation among Graduate STEM Students of Color	2D-10

Thursday, August 5, 1:00pm EDT (10:00am PDT) Plenary Session

Joshua C. Collins, University of Minnesota-Twin Cities

Frameworks to enhance inclusion in physics education: Everyone must participate

The essential work of cultivating inclusive environments in organizations, communities, and society too often falls to those who are themselves members of marginalized and underrepresented groups. This can be especially true in masculinized and male-dominated professions, where the conditions of work and productivity and the valuation of knowledge and skills has historically been defined by those with a combination of dominant social identities, such as being white, being male, being heterosexual, and being cisgender (Collins, 2015). A good example of such a profession is that of physics and physics education. More recently, there have been calls to move the work of inclusion from the margins of such environments more to the center, signaling an important transformation. Such a transformation could prove important in the process of recreating and positioning the work of inclusion as the obligation of everyone, rather than the responsibility of the marginalized and underrepresented.

However, at the same time that movement toward greater inclusion gains traction and momentum, detractors are also organizing themselves to undermine the work. From banning certain words and theoretical frameworks from use in federally-funded organizations (Block, 2020), to instituting bans on transgender participation in the military (Jackson & Kube, 2019), to appointing a woman who does not believe the use of racial slurs in the workplace creates a hostile environment to the Supreme Court (Graziosi, 2020), over the last few years we have been continually subjected to the efforts of these detractors as they held the reins of power. These acts, the impact of which will be felt for years to come, reflect the need to address social injustice as a mechanism for cultivating inclusion.

Byrd (2018b) defined social injustice as “the repression of a person’s individual and civil rights which in the process could hinder their capacity to achieve full potential to learn and perform (Byrd 2014a)” (p. 3). Byrd added: “A social injustice can be either an overt or covert act or behaviour that is intended to demean or degrade by calling attention to the person’s social identity, or to emphasize and remind the person of their marginalized location in society” (2018b, p. 3). I contend that the antidote to social injustice, and the pathway toward inclusion, is social justice, which is defined as “a democratic, participatory, inclusive process and vision” (Byrd, 2018b, p. 7-8) which demands diversity, equity, and inclusion of all.

However, particularly in a masculinized profession such as physics and physics education, for inclusion to be for all, it must become the work of all. No longer can we rely on people from marginalized and underrepresented backgrounds to change the very conditions which sustain their oppression. We must invite everyone to participate in the work of inclusion “to

transcend boundaries of tight knit research networks and invite collaboration across lines of difference" (Byrd 2018a, p. 308). While many people might desire to be inclusive, many also lack the necessary skills to actually forge inclusive environments and structures. Fortunately, there are two useful frameworks for engaging in this process. First, bystander intervention, which is a method of training people to recognize injustice and to intervene to stop it, emphasizes behaviors which can impact the ability of groups of people to create and sustain inclusive environments. Second, ally development, which advances the recognition of injustice and commitment to fighting for the "other," emphasizes the necessary attitudes which inform and inspire inclusivity.

The purpose of this plenary session is to discuss how bystander intervention and ally development frameworks can be utilized in physics education to promote and sustain greater inclusion for marginalized and underrepresented groups by framing inclusion as the obligation and responsibility of everyone. This plenary session will serve as an invitation for those who have historically felt more inclined to sit on the sidelines of social justice efforts, as well as a for of professional development for those who are already committed to the outcome of inclusion.

About Dr. Collins

Joshua C. Collins, EdD, is an Associate Professor and Graduate Program Coordinator of Human Resource Development at the University of Minnesota-Twin Cities. Dr. Collins is also Graduate and Affiliate Faculty in Gender, Women, and Sexuality Studies. He is currently serves on the Board of the Academy of Human Resource Development, as Associate Editor of *New Horizons in Adult Education and Human Resource Development*, and on the Editorial Boards for *Human Resource Development Review*, *Advances in Developing Human Resources*, and *Frontiers in Psychology* (Organizational Psychology section). Dr. Collins has over 60 peer reviewed publications, including 27 peer reviewed journal articles. His research focuses on the inclusion of racial, ethnic, gender, and sexual minorities in educational and organizational settings, utilizing Critical Human Resource Development frameworks to offer alternative modes of thinking and doing, particularly in masculine, male-dominated, and masculinized professions and industries.

Thursday, August 5, 2:00pm EDT (11:00am PDT)
Parallel Session Cluster 2

Doing Physics Education Research Inclusively: Designing for Variation in Participants' Needs, Abilities, and Interests
(Workshop)

Jacquelyn Chini, University of Central Florida
Co-authors: Erin Scanlon, University of Connecticut, Avery Point
Daniel Oleynik, University of Central Florida

In this workshop, participants will consider the role of disability in physics education research (PER). In response to Pugach, Matewos & Gomez-Najarro's (2020) claim that disability remains a "precarious guest" at the social justice table, we will explore options for considering disability as part of diversity in PER. Participants will take up questions posed by Pugach, Matewos & Gomez-Najarro to consider the potential for disability in their own research project. We will describe our development of a tool for critically examining the environments we design (e.g., education research spaces) to identify which categories of abilities (i.e., physical/mobility, visual, hearing, cognitive, health, and emotional/mental health) are privileged and which are simultaneously taxed, and how we have used the tool to analyze our own research project to identify exclusionary practices (i.e., requiring participants to participate in synchronous, spoken interviews) and designed more inclusive options (i.e., allowing participants to participate by asynchronously responding to interview questions in writing). Participants will use the tool to analyze their own research projects to identify instances of exclusionary practices and brainstorm how to incorporate more inclusive practices.

Recommended pre-workshop reflection questions and a suggested article are available at http://tiny.cc/PERC2021

The workshop goals are: 1) Participants will recognize disability as a dimension of identity that should be explored in PER investigations; 2) Participants will identify research practices that privilege and tax certain dimensions of ability.

Equity in Precollege Physics Access, Teaching, and Learning
(Talk Symposium: live presentations)

Angela M. Kelly, Stony Brook University
Co-authors: Robert Krakehl, Stony Brook University and Manhasset High School, NY
Martin Palermo, Stony Brook University and William Floyd High School, NY
Keith Sheppard, Stony Brook University
Dennis M. Robbins, Hunter College, City University of New York

Physics is taken by fewer than one-half of high school graduates in the U.S., and contextual factors related to access, participation, teaching quality, and precursor performance in science and mathematics may provide insights into why students take physics and how they perform in the subject. In this session, a group of physics education researchers will examine precollege physics equity in terms of student-, teacher-, and school-level characteristics that predict physics access and achievement. These studies explore how ethnicity and class are factors in the reproduction of structural inequalities in precollege physics in the U.S. The session will include extended time for a broader discussion where all speakers and the physics education research community may debate policy reforms that will promote more equitable student outcomes.

How did Physics Become a Course for Boys? A History of Gender Enrollment in High School Physics

Primary Contact: Keith Sheppard, Stony Brook University
Co-authors: Dennis M. Robbins, Hunter College, City University of New York

Access to and enrollment in high school physics has until fairly recently been predominantly a privilege of boys. Recent publications have suggested that the gap in gender enrollment has narrowed, and in some instances, become equal. This has often been attributed to the publication of a Nation at Risk in 1983 and the subsequent broad increase in high school graduation requirements in science and mathematics. But has this always been the case? Was the access of girls to physics courses always restricted? This historical study provides an overview of high school physics gender enrollment, starting in the 19th century and tracking forward to the present day. It utilizes both nationwide data from the U.S. Bureau of Education and state-level data from New York State's public schools and academies. As such it provides the historical backbone and context for the rest of this symposium's content. In the past, women enrolled in physics in ways not observed since. In 1890, the number and percentage of women enrolled high school physics in the U.S. were greater than that of men. The early decades of the 20th century marked the beginning of an overall historical decline in the percentage of students taking physics, which reached its nadir in the 1980s shortly before A Nation at Risk was published. Over time, however, the loss of women was much greater and the period of 1900 to 1950 initiated a long-standing educational division between genders. The study also addresses some of the root causes of the differing levels of participation of men and women. Female participation has increased in the last forty years but a persistent chasm between the genders in physics course-taking and credit-earning has been the norm for the last 100 years.

Physics Teacher Retention, Attrition, and Migration

Primary Contact: Martin Palermo, Stony Brook University and William Floyd High School, NY
Co-authors: Angela M. Kelly, Stony Brook University
Robert Krakehl, Stony Brook University and Manhasset High School, NY

Physics is taken by fewer than one-half of high school graduates in the U.S., and contextual factors related to access, participation, teaching quality, and precursor performance in science and mathematics may provide insights into why students take physics and how they perform in the subject. In this session, a group of physics education researchers will examine precollege physics equity in terms of student-, teacher-, and school-level characteristics that predict physics access and achievement. These studies explore how ethnicity and class are factors in the reproduction of structural inequalities in precollege physics in the U.S. The session will include extended time for a broader discussion where all speakers and the physics education research community may debate policy reforms that will promote more equitable student outcomes.

Science and Mathematics Predictors of Precollege Physics Equity, Access, and Performance

Primary Contact: Robert Krakehl, Stony Brook University and Manhasset High School, NY
Co-authors: Angela M. Kelly

The question of precollege physics access and performance has been a persistent concern when considering the goal of diversifying participation in post-secondary STEM study and careers. This study examined academic and demographic predictors of physics enrollment and performance, which may provide insights for academic institutions to compensate for differential access to the social, cultural, and science capital that often influences physics participation and learning. Descriptive and inferential analyses of state-level data (N=1208 high schools enrolling 770,462 students) were conducted to define the scope of physics participation and performance, and the predictive value of ethnicity, socioeconomic class, and prior science and mathematics course enrollments and performance. Physics was taken by fewer students when compared to biology, Earth science, and chemistry, and participation and performance were significantly differentiated by ethnicity and socioeconomic class. Correlation and multiple regression models indicated that although socioeconomic status was the main predictor of student enrollment in physics, participation was mediated by schoolwide enrollment in chemistry and algebra II as well as school-level performance in chemistry and geometry. School-level performance in physics was negatively predicted by the percentage of students traditionally underrepresented in STEM, yet the predictive value was mediated by chemistry and algebra II performance. Results suggest that the science and mathematics sequence negatively predicts physics participation, particularly with regard to students traditionally marginalized in STEM. Students with limited science capital may not enact agency and receive encouragement to pursue physics as an elective. School leaders and policy makers should consider more proactive interventions to promote diverse physics participation and more equitable performance outcomes.

Widening the Gap: Intersectional Analysis of Advanced Placement Physics Participation and Performance by Gender and Ethnicity

Primary Contact: Angela M. Kelly, Stony Brook University
Co-authors: Robert Krakehl, Stony Brook University and Manhasset High School, NY

This quasi-experimental, observational study examined access and performance of students in four Advanced Placement (AP) Physics courses in 2018-19: AP Physics 1 (N=150,451), AP Physics 2 (N=20,466), AP Physics C Mechanics (N=49,951), and AP Physics C Electricity & Magnetism (N=20,449); this analysis utilized an intersectional lens of ethnicity and gender in identifying enrollment and performance disparities. Descriptive and inferential analyses were conducted to determine whether the distribution of student ethnicities and genders for students who took the examinations was similar to that of U.S. schools. Results indicated that AP Physics 1 was a relatively accessible course, though enrollment disparities among genders and ethnicities grew as the AP Physics courses became more advanced with physics and/or calculus prerequisites or corequisites. There were large decreases in course enrollments from first- to second-year AP Physics courses, particularly for women who were also underrepresented ethnic minorities. In terms of performance, AP Physics 1 had the lowest overall weighted average, with the majority of students failing the examination. Women who were traditionally underrepresented ethnic minorities were found to have failure rates of over 80% on the AP Physics 1 examination, and failure rates near 50% for AP Physics 2 and the AP Physics C courses compared to non-minority men who had approximately half the failure rates. In most cases, men outperformed women who shared their ethnicities. These results present opportunities for physics education policy makers and researchers to design interventions for students in intersecting marginalized social groups, many of whom have disproportionately low representation and achievement in advanced high school physics.

How can early-career members of our community shape inclusivity discourse and practice within physics?

(Roundtable Discussion)

Rachel Henderson, Michigan State University
Co-authors: W. Brian Lane, University of North Florida
Thomas Finzell, Michigan State University

As early-career members of our PER community establish themselves and begin to influence their local and broader academic communities, they have opportunities to initiate and shape conversations and practices that impact inclusivity in physics. How can early-career folks make the most of these opportunities presented in their classes, committees, and conferences while navigating their own challenges within existing structures? In this session, we will explore how we can leverage our experiences to improve the landscape of inclusivity for our students, upcoming colleagues, and ourselves. To guide our discussion, we encourage folks to read an article centered on the role of mentoring for early-career physics teachers (Cameron & Grant, 2017). The session will open with a brief introduction and proceed to a roundtable discussion about attendees' perspectives, experiences, and ideas for the future. We plan to conclude with time for networking and informal conversations. We welcome all members of the PER community while actively encouraging people that self-identify as early-career in PER to this roundtable discussion.

Thursday, August 5, 3:30pm EDT (12:30pm PDT)
Parallel Session Cluster 3

Identifying the Resources that Support the Success of African Americans in STEM

(Talk Symposium: live presentations)

Geraldine L. Cochran, Rutgers University

In this session two scholars will share their dissertation work investigating the success of African Americans in STEM. Both of these scholars take an asset-based approach to understand how their participants were successful despite inequities, injustice, and barriers to their success. Both works also center the voices of those marginalized and minoritized in the STEM fields. The first speaker focuses on successful African American males majoring in STEM at a predominantly white institution. The second speaker focuses on successful, African American women with professional careers in STEM within the academy. After the speaker's presentations and brief question and answer each presentation, there will be 20 minutes for a longer conversation with the speakers on the implications of their work for the field of physics education research.

Understanding how African American Women in STEM Overcome Barriers within the Academy

Primary Contact: Nora Howard, Senior Education Consultant

Previous research indicates that African American women often experience social disparities such as race, gender, and class in the academy. Additionally, a lack of adequate mentoring and financial resources to support their research efforts create fundamental challenges for them. In this work, I investigated the barriers African American women overcome in pursuit of academic success in STEM disciplines using a qualitative research method to attend to social, historical, and temporal context. The findings of these studies are tentatively applied; that is, they may be applicable in diverse situations based on comparability of other contexts (Marino, 1995, p. 464). Data for this study included in-depth interviews with five participants, using an open-ended conversational format to facilitate the development of trust, rapport, and maximum elicitation of stories from the participants. The results suggest that African American Women overcome barriers to successful STEM careers through their family and social ties, mentoring relationships, and religious practices.

Understanding the Lived Experiences of Academically Successful Undergraduate Black Men in STEM

Primary Contact: Sharitta F. Gross, ELLA Consulting

The lack of racial diversity and historical racial inequities within the STEM field make focusing on academic success in relation to populations minoritized due to race essential. It is particularly important to understand the experiences of academically successful, talented "Black males whose educational plight pushes them to the wayside" (Grantham, 2011, p. 263). While there is much research on this topic within the body of literature, much of that work takes a deficit approach. The study presented in this paper takes an asset-

based approach designed to capture the lived experiences of 10 academically successful, undergraduate Black males in STEM disciplines within a predominantly white institution. Although the larger study resulted in numerous findings with implications for college faculty and administrators, in this paper we focus on the importance of ethnic diversity amongst faculty and to financial support.

Measuring learning assistants' Pedagogical Content Knowledge for Questioning with a written instrument

(Workshop)

Jianlan Wang, Texas Tech University
Co-authors: Beth Thacker, Texas Tech University
Stephanie Hart, Texas Tech University
Kyle Wipfli, Texas Tech University

Learning assistants (LA) are significant facilitators of student learning in non-traditional introductory physics courses. Questioning is an effective strategy for LAs to interact with students as opposed to directly delivering knowledge to students. We applied the framework of Pedagogical Content Knowledge for Questioning (PCK-Q) to describe LAs' skills of questioning in specific contexts at Hispanic-serving institutions. To measure LAs' PCK-Q, we have developed a written instrument. These questions described various scenarios of LA-student interaction in inquiry-based settings about classical mechanics and electromagnetism. LAs need to articulate how they would support student learning or rank provided responses considering students' difficulties. In this workshop, we will present sample questions and LAs' answers to those questions. We will also present scoring rubrics developed to code LAs' responses and interpret their PCK-Q. From this workshop, participants will practice using the rubrics to score sample questions and we will discuss how this instrument could be used for LA assessment and preparation.

Physics Public Engagement in the COVID Era: Lessons Learned and Moving Forward

(Talk Symposium: live presentations)

Dena Izadi, Department of Physics and Astronomy, Michigan State University
Co-authors: Michael Bennett - JILA NSF Physics Frontier Center, & Department of Physics, University of Colorado Boulder
Claudia Fracchiolla - University College Dublin

Session Goal: confronting barriers to inclusiveness and participation in physics public engagement, by openly discussing the existing challenges in light of the COVID-19 pandemic and beyond.

We present this session as an opportunity for the community to hear from and engage with expert researchers and research-practice partnership members on adaptations in methods and formats of informal physics education efforts. The pandemic has drastically changed the landscape of public engagement in physics, and many programs have developed sophisticated, top-down strategies for continuing activity. Such developments have obviously involved various challenges for program leaders considering the safety restrictions, limited guidelines and available resources. In this session we look to learn about how different programs have adapted and also discuss strategies for assessing the impact of the pandemic on their programs as they move forward. Speakers will give 10-minute talks on their efforts to adapt programming to COVID as well as preliminary research efforts to understand the impact of these novel formats of engagement. Following these talks, the session will break into a 15-20 minute panel discussion involving attendees on the question of research-based techniques for the COVID era, ideas and tips for program adaptation, and questions of institutional support and priorities as universities adapt to the new landscape of education post-pandemic. We look forward to hearing from attendees about their own experiences as well.

Nuclear Science for Everyone

Primary Contact: Zachary Constan, Michigan State University

National Superconducting Cyclotron Laboratory's outreach program normally serves 10,000+ in-person visitors each year for tours, talks, and events. Restrictions due to COVID proved an opportunity to reach an even larger audience through virtual tours, Facebook live talks, and online camps! The presenter will share methods for converting various activities so they are online-accessible and often asynchronous through the use of specific technologies and engagement strategies.

STEM Public Outreach Team (SPOT) Impact and Adaptation

Primary Contact: Joey Key, University of Washington Bothell

The University of Washington Bothell (UWB) STEM Public Outreach Team (SPOT) trains undergraduate students to give presentations and lead activities related to current STEM research topics. During 2020 and 2021 the SPOT program pivoted to online classrooms and events with adaptations that will carry forward. Access and availability for the SPOT Student Ambassadors as well as the participating schools and community groups has been expanded through online engagement options. The SPOT program collaborates with the UW Center for Evaluation and Research for STEM Equity (CERSE) on Evaluating the Impact of Participation in STEM Outreach on Persistence of Diverse Students in Physics, Math, and Engineering.

The Resilience and Response of Planetariums during the COVID-19 Pandemic

Primary Contact: Shannon Schmoll, Michigan State University

Planetariums have been hard hit by COVID-19. The very nature of the work done by planetariums is to use immersive spaces to help transport people to different locations. However, a majority of planetariums have found ways to still engage their audiences during difficult times. This has included using various softwares to recreate the night sky, 360 degree YouTube streams to stream planetarium shows virtually but still immersively, and relying on other informal learning programming from demos and talks to remain connected to audiences. In this particular presentation we will explore specifically how the Abrams Planetarium utilized softwares including Stellarium, WorldWide Telescope, and OBS as well as platforms such as YouTube and Facebook to engage with audiences while closed. Results from a rapid report on how planetariums were doing in the summer of 2020 will also be shared to offer a broader picture of how different planetariums handled the pandemic.

Understanding the Roles of Informal Physics Personnel

Primary Contact: Bryan Stanley, Michigan State University

Physicists, physics students, and public audiences gather in informal physics learning environments in a variety of formats like youth camps, public lectures, and demo shows. We are interested in understanding the roles, tasks, and interactions that program personnel have in these programs to determine what factors are important for the design and implementation of meaningful informal physics activities. COVID disrupted the way that many informal physics programs have operated, including personnel participation. In our qualitative research study, we interviewed lead program facilitators, administered surveys, and conducted site visits to multiple programs to investigate key themes and challenges of informal physics programs. This is a continuation of our work to identify the key components of informal physics programs that facilitators have influence over, such as recruitment, program content, and the distribution of tasks. Here, we discuss our current model of the key components of personnel, and consider the implications of COVID.

Thursday, August 5, 4:30pm EDT (1:30pm PDT)
Closing Session: Panel Discussion

Join us for the closing session as three conference participants reflect on this year's conference and its meaning for Physics Education Research. The reflections will be followed by a live question and answer session with the PERC audience.

Conference participants who will be leading this discussion:

Carolina Alvarado is an Assistant Professor in the Department of Science Education at California State University, Chico. Dr. Alvarado's research interests include building collaborative communities among in-service K-12 science teachers and pre-service K-12 science teachers, with a main focus on fostering the recognition of students' valuable ideas to create responsive science classrooms.

Zahra Hazari is a professor in the Department of Teaching and Learning and the STEM Transformation Institute as well as an affiliate faculty member in the Department of Physics. Dr. Hazari's research focuses on reforming physics learning environments in an effort to improve critical educational outcomes for under-represented groups in physics, especially women.

Xandria Quichocho (they/he/she) is a Black + Chamorro physicist recently graduated with a B.S. in Physics from Texas State University and is currently pursuing their Physics Ph.D. in the Physics Education Research Lab at Michigan State University. Their main research focused on how the intersections of race, gender, and sexuality interact with women of color and LGBTQ+ women's identity as physicists.