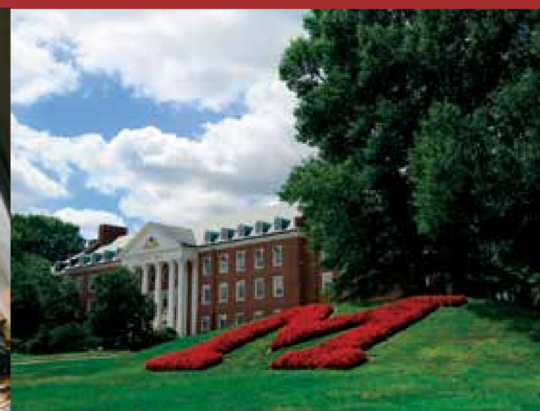
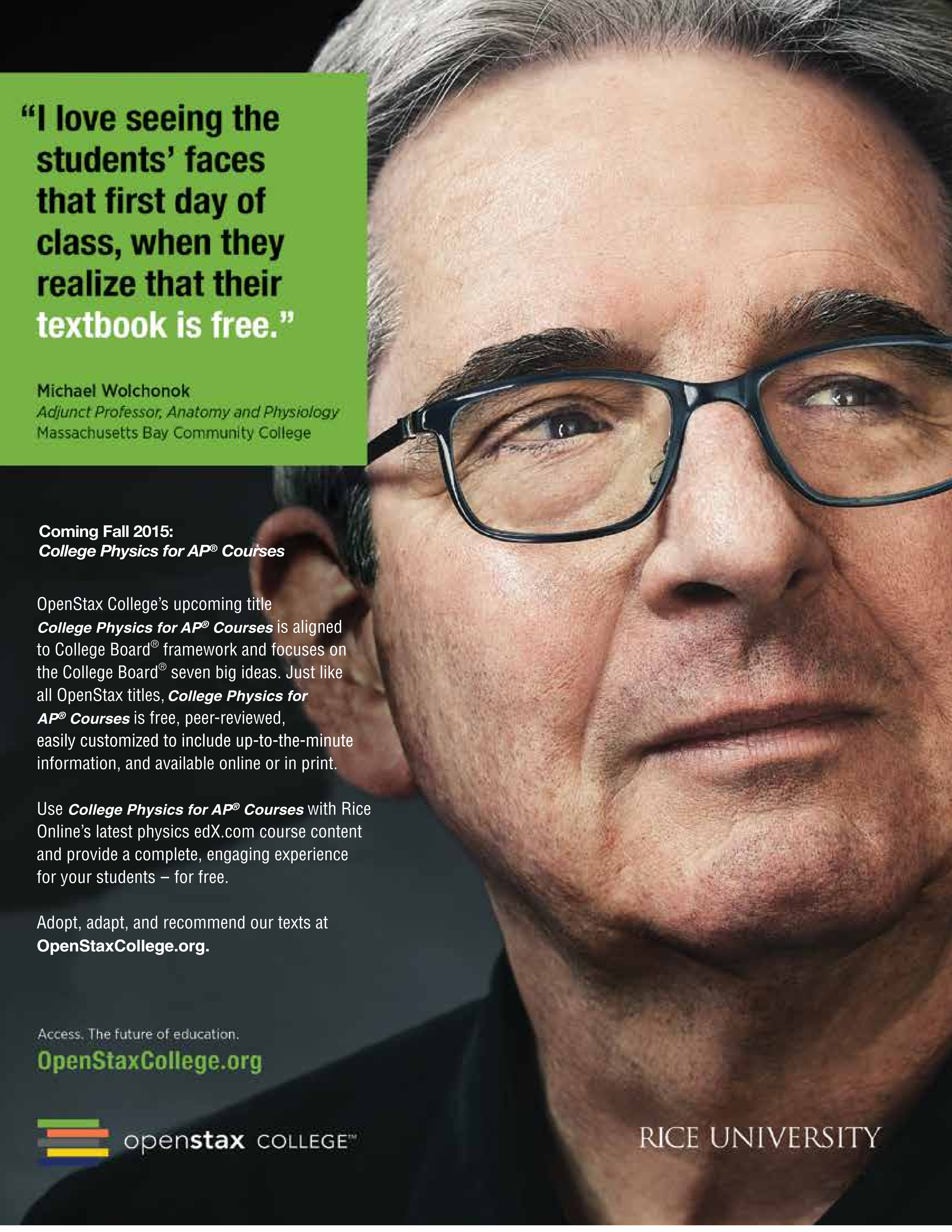
2015 AAPT Summer Meeting

AAPT American Association of Physics Teachers

College Park, Maryland
July 25–29th


"I love seeing the students' faces that first day of class, when they realize that their textbook is free."
Michael Wolchonok
Adjunct Professor, Anatomy and Physiology
Massachusetts Bay Community College
Coming Fall 2015:
College Physics for AP® Courses
OpenStax College's upcoming title College Physics for AP® Courses is aligned to College Board® framework and focuses on the College Board® seven big ideas. Just like all OpenStax titles, College Physics for AP® Courses is free, peer-reviewed, easily customized to include up-to-the-minute information, and available online or in print.
Use College Physics for AP® Courses with Rice Online's latest physics edX.com course content and provide a complete, engaging experience for your students – for free.
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AAPT 2015 SUMMER MEETING
JULY 25-29 COLLEGE PARK, MD

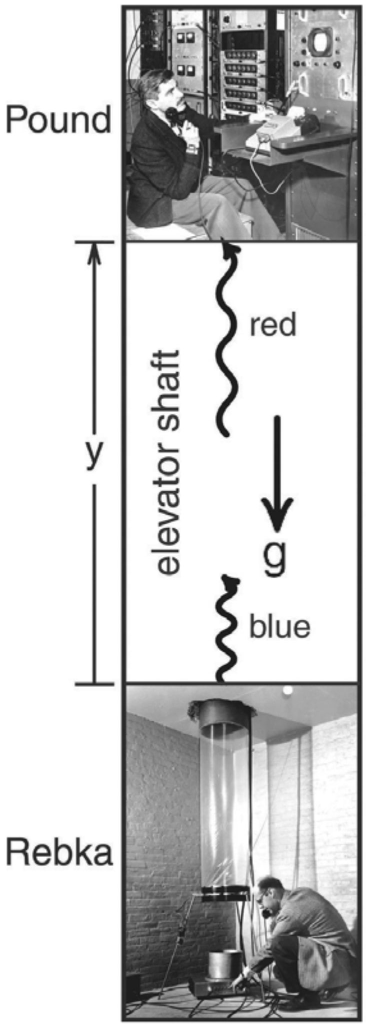
College Park, MD
July 25-29, 2015

University of Maryland

American Association of Physics Teachers
One Physics Ellipse
College Park, MD 20740
301-209-3333
www.aapt.org

PHYSICS2000 WORKSHOPS ON

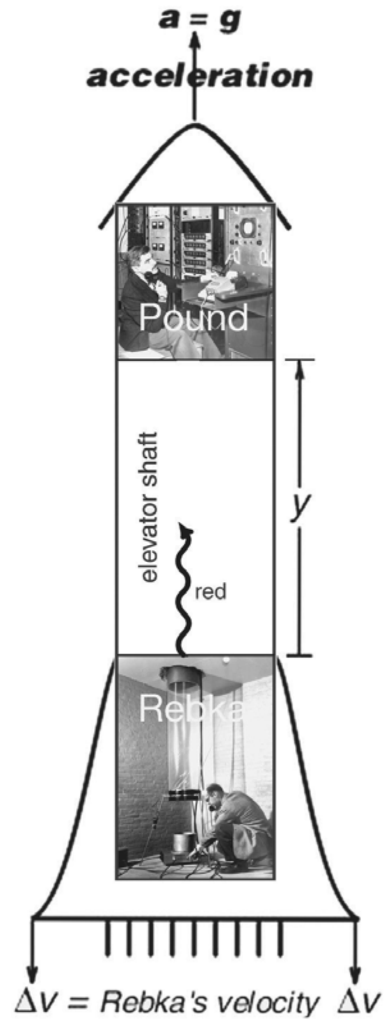
Bringing General Relativity Into Introductory Physics



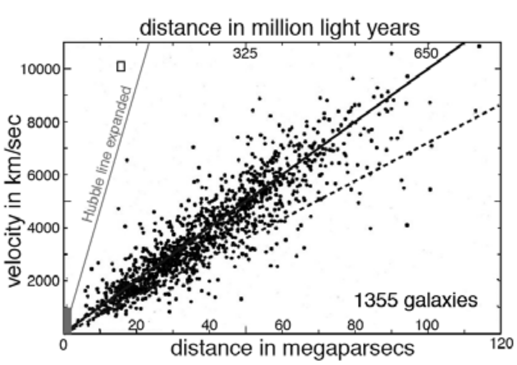
Free Workshop 1
Pound Rebka Experiment and Cosmology

Monday
12:00 - 1:00 PM
SSU -
Margaret Brent B

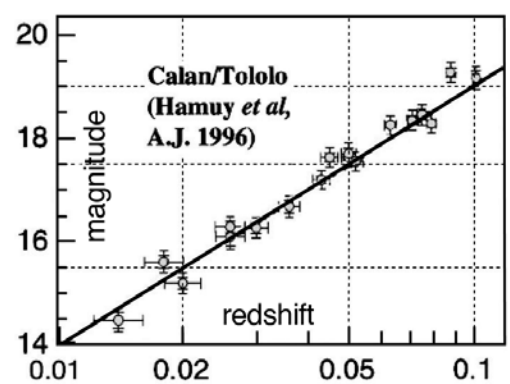
In general relativity, a uniform gravitational field uniformly expands (or contracts) space.



Free Workshop 2
Peculiar Velocity



Tuesday
12:00 - 1:00 PM
SSU -
Prince George's Room



Why is it that CERN cannot push a tiny proton as fast as the speed of light, while the very weak repulsive gravitational field of dark energy can push entire galaxies away from us faster than the speed of light. Astronomers have given us an answer.

AAPT Sustaining Members

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

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Facebook/Twitter at Meeting

We will be tweeting and posting updates to Facebook, before, during, and after the meeting to provide you with details and helpful tips. Participate in the conversation by reading the latest tweets at ***http://twitter.com/AAPTHQ*** or search the ***hashtag #aaptsm15***. Don't forget to include that hashtag in your tweets! Make sure to check social media and the program app for any changes to the schedule, cancellations, and general announcements during the meeting.

Follow us to stay up to the minute!

Like us on Facebook at ***http://facebook.com/AAPTHQ*** and follow us at ***@AAPTHQ*** on Twitter

Special Thanks

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

Local organizers:

Andrew Baden, University of Maryland, College Park
Richard Berg, University of Maryland, College Park
Donna Hammer, University of Maryland, College Park

Special thanks to John Layman, Emeritus Professor, University of Maryland and American Association of Physics Teachers Historian

Paper sorters:

George Amann (Incoming Program Chair for WM15)
Janelle Bailey (2015 Program Chair/President Elect)
Sean Bentley (SPS Contributions)
Dan Crowe (High School Committee)
Andrew Duffy (Executive Programs Committee)
Kathleen Falconer (Programs Committee)
Joe Heafner (Committee on Physics in Two-Year Colleges)
Mike Loverude (RiPE Committee)
Ellie Sayre (PER Leadership Organizing Council)
Aaron Titus (Awards Committee)
Adrienne Traxler (Committee on Women in Physics)

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Beth A. Cunningham, (ex officio)
AAPT Executive Officer

Contacts:

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301-209-3340; programs@aapt.org

Tiffany Hayes, Director, Programs & Conferences
Cerena Cantrell, Associate Director, Programs & Conferences
Janet Lane, Programs Administrator
Pearl Watson, Meetings Logistics & Registration Coordinator
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Promoting Professional Learning in Physics

AAPT PTRA

30th Anniversary 1985-2015

World Scientific
www.worldscientific.com

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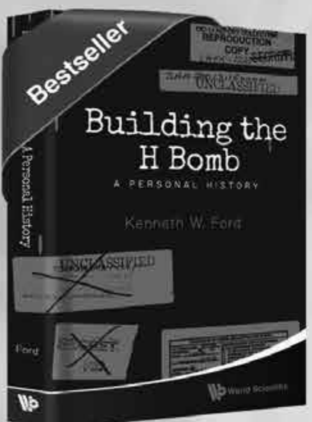
www.icpress.co.uk

New & Bestselling titles in Popular Science



Building the H Bomb

A Personal History

by **Kenneth W Ford**

> "H-Bomb Physicist's Book Runs Afoul of Energy Department"
>
> *The New York Times 23 March 2015*

A memoir of Kenneth Ford recounting the time he spent building the first hydrogen bomb with some of the scientific giants of that time, interleaved with brief tales of his life away from weapons. This volume brings out Project Matterhorn's previously unheralded major contribution to the development of nuclear weapons.

240pp **Mar 2015**
978-981-4632-07-2 **US$58**
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Einstein Relatively Simple

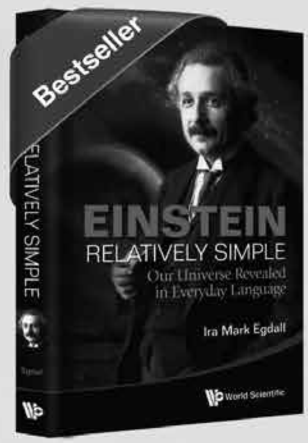
Our Universe Revealed in Everyday Language

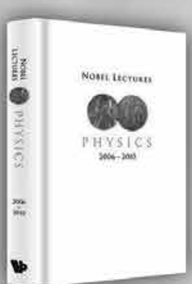
by **Ira Mark Egdall** *(Florida International University, The University of Miami & Nova Southeastern University, USA)*

"He covers the main topics of special and general relativity in a refreshing, personal way. This is a well-crafted, well-documented text with extensive endnotes, in which a bibliography is embedded. He introduces readers to his own unique entry into this very populous genre. Valuable for inquisitive nonscientists."

CHOICE

400pp **Jan 2014**
978-981-4525-58-9 **US$59**
978-981-4525-59-6(pbk) **US$28**





Nobel Lectures in Physics

(2006 – 2010)

edited by **Lars Brink** *(Chalmers University of Technology, Sweden)*

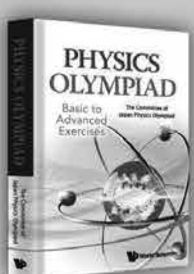
384pp **Jun 2014**
978-981-4612-67-8 **US$78**
978-981-4612-68-5(pbk) **US$34**

Birds and Frogs

Selected Papers of Freeman Dyson, 1990–2014

by **Freeman J Dyson** *(IAS, Princeton)*

376pp **Mar 2015**
978-981-4602-85-3 **US$58**
978-981-4602-86-0(pbk) **US$28**



Physics Olympiad

— Basic to Advanced Exercises

by **The Committee of Japan Physics Olympiad**

380pp **Jan 2014**
978-981-4556-67-5(pbk) **US$48**

Time in Powers of Ten

Natural Phenomena and Their Timescales

by **Gerard 't Hooft & Stefan Vandoren** *(Utrecht University, The Netherlands)*

translated by **Saskia Eisberg- 't Hooft**

232pp **May 2014**
978-981-4489-80-5 **US$78**
978-981-4489-81-2(pbk) **US$24**

Enter WSAAPT20 to enjoy a 20% discount!
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Meeting-at-a-Glance

Meeting-at-a-Glance includes sessions, workshops, committee meetings, and other events, including luncheons, Exhibit Hall hours and snacks, plenary sessions, poster sessions, and receptions. All rooms will be in either The Stamp Student Union **(SSU)**, *Physical Sciences Complex* **(PSC)** *Art-Sociology Building* **(ASY)**, *Jimenez Hall* **(JMZ)**, *Glen L. Martin Hall* **(EGR)**, *John S. Toll Physics Building* **(PHY),** or the Marriott.

FRIDAY, July 24

10 a.m.–12 p.m.		National Institute of Standards and Technology (NIST)	Offsite
1–3 p.m.		NASA Goddard Visitor Center Tour	Offsite
4–7 p.m.		**REGISTRATION**	**Stamp Student Union Foyer**

SATURDAY, July 25

7 a.m.–4 p.m.		**REGISTRATION**	**Stamp Student Union Foyer**
8–11 a.m.	W01	Tour of Neils Bohr Archive and Library (Bus from Stamp Student Union)	American Center for Physics
8 a.m.–12 p.m.	W03	FPGAs	PHY - 3301
8 a.m.–12 p.m.	W04	Ramps Bungee Cords: Bringing It Together—Modeling, Assessment and Engineering	PHY - 3213
8 a.m.–12 p.m.	W05	Data Analysis for Astronomy Educators	PHY - 1201
8 a.m.–12 p.m.	W06	Integrating Physics and Geology into Engineering for STEM	PHY - 3115
8 a.m.–5 p.m.	W07	Learn Physics While Practicing Science: Introduction to ISLE	PHY - 3220
8 a.m.–5 p.m.	W08	PIRA Lecture Demonstrations I	PHY - 1412
8 a.m.–5 p.m.	W09	Activity-based Physics in the High School Classroom	PHY - 3104
8 a.m.–5 p.m.	W10	Teaching Programming and Problem Solving Using LEGO EV3 Robotics	PHY - 3120
8 a.m.–5 p.m.	W11	Teaching Graphical Solutions for Forces and Kinematics	PHY - 1204
1–5 p.m.		The Physics of Racing Workshop	Offsite
1–5 p.m.	W12	Open Source Electronics for Laboratory Physics	PHY - 3316
1–5 p.m.	W13	Research-based Reforms to Introductory Physics for the Life Sciences	PHY - 3310
1–5 p.m.	W14	Physics Research Mentor Training	PSC - 3150
1–5 p.m.	W15	Preparing Faculty to Mentor Physics Students for Careers: Using the Careers Toolbox	PSC - 2136
1–5 p.m.	W16	Integrating Direct-Measurement Videos into Physics Instruction	PHY - 1201
1–5 p.m.	W17	Labs that May Appear at Many Levels	PHY - 3214
1–5 p.m.	W18	Creating Interactive Web Simulations Using HTML5 and Javascript	PHY - 3306
6–7:15 p.m.		Nominating Committee I	Marriott - 0101
6–9 p.m.		AAPT Executive Board I	Marriott - 2110/2111

SUNDAY, July 26

7 a.m.–4 p.m.		**REGISTRATION**	**SSU-Foyer**
8–10 a.m.		Publications Committee	Marriott - 0101
8–10 a.m.		Meetings Committee	Marriott - 0105
8 a.m.–12 p.m.	W19	Demo Kit in a Box	PHY - 3306
8 a.m.–12 p.m.	W20	Making Interactive Video Vignettes and Interactive Web Lectures	PHY - 3104
8 a.m.–12 p.m.	W21	Just-in-Time Teaching	PHY - 3120
8 a.m.–12 p.m.	W22	Explorations in Arduino Physics: Ideas and Experiments	PHY - 3115
8 a.m.–12 p.m.	W23	Authentic Experimentation in Labs Using Structured Quantitative Inquiry	PHY - 3213
8 a.m.–12 p.m.	W24	Creating Invention Tasks that Develop Flexible Math. Reasoning Skills in Physics	PHY - 3220
8 a.m.–12 p.m.	W25	Beyond the Atom	PHY - 3214
8 a.m.–12 p.m.	W26	Research-based Tools for Teaching Quantum Mechanics	PHY - 1201
8 a.m.–12 p.m.	W27	Computational Physics	PHY - 3316
8 a.m.–12 p.m.	W28	Interactive Engagement in Upper-division: Methods and Materials from CU-Boulder	PHY - 1204
8 a.m.–12 p.m.	W29	Activities for Learning About Climate and Climate Change	PHY - 0405
8 a.m.–5 p.m.	W30	NEXUS Physics Labs for Biology Students	PHY - 3310
8 a.m.–5 p.m.	W31	Creating JavaScript Simulations and Electronic Books for Computers and Tablets	PHY - 3312
8 a.m.–5 p.m.	W32	Preparing to Teach Physics to the Next Generation	PHY - 3203
8 a.m.–5 p.m.	W33	PIRA Lecture Demonstrations II	PHY - 1410
10:30 a.m.–1:30 p.m.		Resource Letters Committee	Marriott - 0102

10:30 a.m.–4 p.m.		AAPT Executive Board II	Marriott - 2110/2111
1–5 p.m.	W34	Modeling Instruction for University Physics	PHY - 1201
1–5 p.m.	W35	Metacognition and Reasoning in Physics	PHY - 3220
1–5 p.m.	W36	Physics Union Mathematics	PHY - 3120
1–5 p.m.	W37	Fun, Engaging and Effective Labs and Demos with Clickers, Video Analysis	PHY - 3104
1–5 p.m.	W38	Physics of Toys I: Force, Motion, Light, and Sound	PHY - 3306
1–5 p.m.	W39	Facilitating Student Self-reflection & Personalized Instructor Feedback	PSC - 2136
1–5 p.m.	W40	Strategies to Help Women Succeed in Physics Related Professions	PHY - 1304
1–5 p.m.	W41	Periscope: Looking into Learning in Best-practices University Physics Classrooms	PSC - 3150
1–5 p.m.	W42	Intermediate and Advanced Laboratories	PSC - 3214
1–5 p.m.	W43	Next Generation Physics and Everyday Thinking	PHY - 1204
5–6 p.m.		AAPT Official Tweet-up	SSU - Juan Ramon Jimenez
5–6 p.m.		Tour of Physical Sciences Complex	PSC
5:30–6:30 p.m.		Programs Committee I	SSU - Charles Carroll A
5:30–8 p.m.		Section Representatives / Section Officers	SSU - Charles Carroll B
5:30–9 p.m.		**EVENING REGISTRATION**	SSU - Foyer
6–8 p.m.		High School Share-A-Thon	SSU - Benjamin Banneker A
6:30–7:45 p.m.		Committee on Interests of Senior Physicists	SSU - Benjamin Banneker B
6:30–7:45 p.m.		Committee on Teacher Preparation	SSU - Margaret Brent A
6:30–7:45 p.m.		Committee on Physics in Undergraduate Education	SSU - Charles Carroll A
6:30–7:45 p.m.		Committee on Women in Physics	SSU - Margaret Brent B
6:30–7:45 p.m.		ALPhA Committee	SSU - Juan Ramon Jimenez
6:30–7:45 p.m.		Executive Programs Committee	SSU - Pyon Su
6:30–8 p.m.		Physics Fair Play Production	SSU - Hoff Theater
8–10 p.m.		**Exhibit Hall Opens / Welcome Reception**	SSU - Grand Ballroom
8–10 p.m.		High School Teachers Resource Booth (323)	SSU - Grand Ballroom
8–10 p.m.		PIRA Resource Room	SSU - Grand Ballroom Lounge
8–10 p.m.		TYC Resource Room	SSU - Nanticoke
8–10 p.m.		High School Physics Photo Contest Viewing & Voting	SSU - Grand Ballroom Lounge
8–10 p.m.		SPS Undergraduate Research and Outreach Poster Session and Liquid Nitrogen Demo and Ice Cream	SSU - Grand Ballroom

MONDAY, July 27

7 a.m.–5 p.m.		**REGISTRATION**	**SSU - Foyer**
7–8 a.m.		**First Timers' Breakfast**	SSU - Prince George's
7–8:15 a.m.		Committee on Educational Technologies	SSU - Benjamin Banneker A
7–8:15 a.m.		Committee on Graduate Education in Physics	SSU - Benjamin Banneker B
7–8:15 a.m.		Committee on Science Education for Public	SSU - Charles Carroll A
7–8:15 a.m.		Committee on Diversity in Physics	SSU - Charles Carroll B
8–9 a.m.	**CW02**	Physics with PASCO scientific, featuring PASCO Capstone™	SSU - Margaret Brent A
8:30–9 a.m.	AK	Innovation and Entrepreneurship	SSU - Atrium
8:30–9:30 a.m.	AD	Mechanics Modeling Meets the New AP Physics I	PHYS - 1410
8:30–9:40 a.m.	AG	PIRA Session: Biophysics Demos and Apparatus	SSU - Benjamin Banneker B
8:30–9:50 a.m.	AC	Increasing Access to Grad School	ASY - 2203
8:30–9:50 a.m.	AF	Photographic Techniques New and Old	SSU - Benjamin Banneker A
8:30–10 a.m.	AA	Astronomy in the Physics Classroom	JMZ - 0105
8:30–10 a.m.	AB	History of Physics in Other (non-European) Cultures	JMZ - 0220
8:30–10 a.m.	AE	PER: Examining Content Understanding and Reasoning I	PHYS - 1412
8:30–10 a.m.	AH	Teaching Sustainability in the Majors Curriculum	SSU - Charles Carroll A
8:30–10 a.m.	AI	Technology in the Physical Science Classroom	SSU - Charles Carroll B
8:30–10 a.m.	AJ	Undergraduate Research and Capstone Projects I	ASY - 2309
9–10 a.m.	AL	Make, Play and Learn	SSU - Atrium
9–10 a.m.		Guest / Spouse Gathering	SSU - Crossland
9–10 a.m.	**CW02B**	Physics with PASCO scientific, featuring PASCO Capstone™	SSU - Margaret Brent A
9–10 a.m.	**CW09**	Sapling Learning: Online Homework with Targeted Instructional Feedback	SSU - Margaret Brent B
9–10:30 a.m.	**CW05**	Perimeter Institute: Drawing Students into Black Hole Physics	SSU - Prince George's

9:30–10:30 a.m.	**CW10**	It's About Time: Active Physics: Leading Project-based High School Physics Program	SSU - Juan Ramon Jimenez
10 a.m.–5 p.m.		**Exhibit Hall Open (coffee break, 10 a.m.)**	SSU - Grand Ballroom
10 a.m.–5 p.m.		High School Physics Photo Contest Viewing & Voting	SSU - Grand Ballroom Lounge
10 a.m.–5 p.m.		High School Physics Teachers Resource Booth (323)	SSU – Grand Ballroom
10 a.m.–5 p.m.		PIRA Resource Room	SSU - Grand Ballroom Lounge
10 a.m.–5 p.m.		TYC Resource Room	SSU - Nanticoke
10:15–10:30 a.m.		Monday Fitness Tracker Raffle Drawing	SSU - Grand Ballroom
10:30 a.m.–12 p.m.	**Awards**	**AAPT Excellence in Teaching Awards, Distinguished Service Citations**	**SSU - Hoff Theater**
12–1 p.m.	**CW01**	The Expert TA: Closing the Gap Between Homework and Test Scores	SSU - Juan Ramon Jimenez
12–1 p.m.	**CW06**	Perimeter Institute: What's New in Physics	SSU - Atrium
12–1 p.m.	**CW11**	Physics 2000	SSU - Margaret Brent B
12–1:15 p.m.		Review Board	SSU - Margaret Brent A
12–1:15 p.m.		Physics Bowl Advisory Committee	SSU - Crossland
12–1:30 p.m.		**High School Physics Teachers' Day Luncheon**	SSU - Prince George's
12–1:30 p.m.		Early Career Professional Speed Networking Event	PSC - Foyer
12–1:30 p.m.	TOP01	Solo PER Faculty Topical Discussion	SSU - Benjamin Banneker A
12–1:30 p.m.	TOP02	Web Resources for Teaching Astronomy Topical Discussion	SSU - Benjamin Banneker B
12–1:30 p.m.	TOP03	Communication Difficulties with Students Topical Discussion	SSU - Charles Carroll A
12–1:30 p.m.	TOP04	AAPT/APS Joint Task Force on Undergraduate Physics Programs: An Update	SSU - Charles Carroll B
12:30–1:30 p.m.		Tour of Physical Sciences Complex	PSC
1:30–2:30 p.m.	**CW03**	WebAssign: Enrich Your Physics Course with WebAssign Additional Resources	SSU - Margaret Brent B
1:30–3:20 p.m.	BB	Developing Experimental Skills in the Laboratory	ASY - 2309
1:30–3:30 p.m.	BA	Panel: Assessment Methods and Issues	ASY - 2203
1:30–3:30 p.m.	BC	Digital Library Resources for Teaching Physical Science	JMZ - 0105
1:30–3:30 p.m.	BD	Panel: First Year Physics Teachers: Insights & Experiences	JMZ - 0220
1:30–3:30 p.m.	BF	PER in the Upper Division I	SSU - Atrium
1:30–3:30 p.m.	BG	PER: Informing Physics Instruction	PHY - 1412
1:30–3:30 p.m.	BH	Panel: PER Using MOOCs	PHY - 1410
1:30–3:30 p.m.	BI	Preparing to Teach Physics to the Next Generation	EGR - 1202
2–3:30 p.m.	BE	LHC in the Classroom	SSU - Charles Carroll A
2–3:30 p.m.	BJ	Teaching Physics in an IB School	SSU - Benjamin Banneker A
2–3:30 p.m.	BK	The Art and Science of Teaching	SSU - Benjamin Banneker B
2–3:30 p.m.	BL	What's Working in Other Disciplines: Recruitment and Retention	SSU - Charles Carroll B
3:30–4 p.m.		**Exhibit Hall: Afternoon Break**	SSU - Grand Ballroom
3:45–4 p.m.		Monday Solo Beats Headphones Raffle Drawing	SSU - Grand Ballroom
4–4:50 p.m.	CB	Adapting the Teacher In Residence (TIR) Role to Local Contexts	SSU - Benjamin Banneker A
4–5 p.m.	CM	Interactive Lecture Demonstrations – What's New?	SSU - Charles Carroll B
4–5 p.m.	CK	Carnival Knowledge	SSU - Prince George's
4–5:50 p.m.	CA	K-12 PER I	SSU - Charles Carroll A
4–5:50 p.m.	CE	Integrating Computational Physics at the Introductory Level	ASY - 2203
4–5:50 p.m.	CG	Introductory Labs/Apparatus	SSU - Benjamin Banneker B
4–5:50 p.m.	CH	PER: Diverse Investigations I	PHY - 1412
4–5:50 p.m.	CI	PER: Identity and Student Engagement	SSU - Atrium
4–6 p.m.	CF	Introductory Courses I	ASY - 2309
4-6 p.m.	CC	Best Practices in Educational Technology I	JMZ - 0105
4–6 p.m.	CD	Frontiers in Astronomy	JMZ - 0220
4–6 p.m.	CJ	PER in the Upper Division II	PHY - 1410
5:10–5:50 p.m.	CL	Physics Majors and Careers	SSU - Charles Carroll B
6–7:30 p.m.		SPS Awards Reception	PSC - Foyer
6–7:30 p.m.	TOP05	Physics and Society Topical Discussion	SSU - Benjamin Banneker A
6–7:30 p.m.	TOP06	Graduate Student Topical Discussion	SSU - Benjamin Banneker B
6–7:30 p.m.	TOP07	Proposed AAPT Governance Changes I	SSU - Juan Ramon Jimenez
6:15–7:15 p.m.		First Timers' Meetup	SSU - Prince George's
6:15–7:30 p.m.		Committee on Apparatus	SSU - Charles Carroll A
6:15–7:30 p.m.		Committee on Physics in High Schools	SSU - Atrium
6:15–7:30 p.m.		Committee on International Physics Education	SSU - Margaret Brent A

6:15–7:30 p.m.		Committee on Space Science and Astronomy	SSU - Crossland
6:15–7:30 p.m.		Committee on Professional Concerns	SSU - Pyon Su
7:30–8:30 p.m.	**Plenary**	APS Plenary: Professor James Gates, University of Maryland	**SSU - Hoff Theater**
8:30–10 p.m.		PTRA Advisory Committee	SSU - Benjamin Banneker A
8:30–10 p.m.		Poster Session 1	SSU - Colony Ballroom

TUESDAY, July 28

6:30–8 a.m.		AAPT Fun Run/Walk	Marriott Foyer
7 a.m.–4 p.m.		**REGISTRATION**	**SSU - Foyer**
7–8 a.m.		Venture / Bauder Endowment Committee	SSU - Margaret Brent A
7–8 a.m.		COGS (Governance Structure)	SSU - Margaret Brent B
7:30–8:30 a.m.		Two-Year College Breakfast	SSU - Pyon Su
8:30–9:30 a.m.	DA	Panel: Transitioning to AP 1 & 2	SSU - Benjamin Banneker A
8:30–9:40 a.m.	DD	Coordinating Outreach with Community Science Centers	SSU - Charles Carroll B
8:30–10 a.m.	DH	Mentoring and Induction of Entering Physics Teachers	JMZ - 0220
8:30–10 a.m.	DI	Diverse Investigations II	PHY - 1410
8:30–10 a.m.	DJ	Panel: Physics Education Policy	PHY - 1412
8:30–10 a.m.	DK	Panel: Succeeding as a Solo Physics Education Researcher	ASY - 2203
8:30–10 a.m.	DL	Upper Division Undergraduate Courses and Labs	ASY - 2309
8:30-10:10 a.m.	DE	Finding Resources in History of Physics Suitable for Classroom Use	SSU - Juan Ramon Jimenez
8:30–10:15 a.m.	DB	Attracting Women to Physics and Girls to Science: What is Working?	SSU - Benjamin Banneker B
8:30–10:20 a.m.	DF	Interactions of Gender and STEM Environments	SSU - Charles Carroll A
8:30–10:30 a.m.	DC	Bringing Physics to Life	SSU - Atrium
8:30–10:30 a.m.	DG	Improving Students' Problem Solving, Reasoning, and Metacognitive Skills	JMZ - 0105
9–10 a.m.	**CW04**	WebAssign 101: Getting Started with WebAssign	SSU - Margaret Brent B
9–10 a.m.	**CW12**	It's About Time: What's New in Next Generation Physics and Everyday Thinking	SSU - Margaret Brent A
9:30–10:30 a.m.	**CW15**	Science First: Saving Valuable Lesson Preparation Time by Using curricuLAB	SSU - Prince George's
10 a.m.–4 p.m.		**Exhibit Hall Open (coffee break, 10:15 a.m.)**	SSU - Grand Ballroom
10 a.m.–4 p.m.		High School Physics Teachers Resource Booth (323)	SSU - Grand Ballroom
10 a.m.–4 p.m.		PIRA Resource Room	SSU - Grand Ballroom Lounge
10 a.m.–4 p.m.		TYC Resource Room	SSU - Nanticoke
10 a.m.–4 p.m.		High School Physics Photo Contest Viewing & Voting	SSU - Grand Ballroom Lounge
10:30–10:45 a.m.		Tuesday Samsung Galaxy Tablet Raffle Drawing	SSU - Grand Ballroom
10:45 a.m.–12 p.m.	**Awards**	**Klopsteg Memorial Lecture Award–David Weintraub, AAPT Fellows Recognition**	**SSU - Hoff Theater**
12–1 p.m.	**CW07**	Perimeter Institute: The Expanding Universe	SSU - Atrium
12–1 p.m.	**CW13**	Physics2000	SSU - Prince George's
12–1:15 p.m.		Committee on Physics in Two-Year Colleges	SSU - Benjamin Banneker A
12–1:15 p.m.		Committee on Laboratories	PHY - 1204
12–1:15 p.m.		Committee on History & Philosophy in Physics	SSU - Benjamin Banneker B
12–1:15 p.m.		Committee on Physics in Pre-High School Education	SSU - Charles Carroll A
12–1:15 p.m.		Committee on Research in Physics Education	SSU - Charles Carroll B
12–1:15 p.m.		PIRA Committee	PHY - 1201
12–1:30 p.m.		Retired Physicists' Luncheon	SSU - Adele's Restaurant
12:30–1:30 p.m.		Tour of Physical Sciences Complex	PSC
1–3 p.m.	**CW14**	Vernier: Experiments and Data Collection with Vernier	SSU - Juan Ramon Jimenez
1:30–2:20 p.m.	EF	High School	JMZ - 0105
1:30–2:30 p.m.	EL	Astronomy	SSU - Atrium
1:30–3:20 p.m.	EH	Lab Guidelines Focus Area 1: Constructing Knowledge	ASY - 2203
1:30–3:30 p.m.	EA	**Al Bartlett Memorial Session**	SSU - Benjamin Banneker A
1:30–3:30 p.m.	EB	Best of European and Middle East Projects	SSU - Benjamin Banneker B
1:30–3:30 p.m.	EC	Best Practices in Educational Technology II	SSU - Charles Carroll A
1:30–3:30 p.m.	ED	Do You Want to Teach at a Community College?	SSU - Charles Carroll B
1:30–3:30 p.m.	EG	Improving Departmental Climate for Women and Under-represented Ethnic Groups	JMZ - 0220
1:30–3:30 p.m.	EI	PER: Examining Content Understanding and Reasoning II	PHY - 1412
1:30–3:30 p.m.	EJ	Research on ExtraSolar Planets	PHY - 1410

1:30–3:30 p.m.	EK	Research on Teamwork	ASY - 2309
1:30–3:40 p.m.	EE	Effective Practices in Physics Teacher Preparation	SSU - Prince George's
3–4 p.m.	**CW08**	Perimeter Institute: Curved Space-time in the Classroom	SSU - Atrium
3:30–4 p.m.		**Afternoon Coffee Break in Exhibit Hall**	SSU - Grand Ballroom
3:45–4 p.m.		Tuesday Smart Watch Raffle Drawing	SSU - Grand Ballroom
4–5 p.m.	**Awards**	**AIP Andrew Gemant Award – Ainissa Ramirez**	**SSU - Hoff Theater**
5–6:30 p.m.		Poster Session 2	SSU - Colony Ballroom
6:15–7:45 p.m.		Night at the Museum (Bus leaves from Stamp Student Union)	College Park Aviation Museum
8–9 p.m.		Demo Show	PHY - 1410/1412

WEDNESDAY, July 29

7–8:30 a.m.		Programs Committee II	Marriott - 0105
7–8:30 a.m.		Awards Committee	Marriott - 0101
7:30–8:30 a.m.		Finance Committee	Marriott - 2111/2110
8 a.m.–3 p.m.		**REGISTRATION**	**SSU - Foyer**
8 a.m.–3 p.m.		High School Physics Photo Contest Winners	SSU - Foyer
8:30–9:30 a.m.	FI	Tesla Coils	ASY - 2309
8:30–9:30 a.m.	FK	Astronomy Education Research	SSU - Benjamin Banneker A
8:30–10 a.m.	FG	Recruiting, Retaining and Outreach to Under-represented High School Teachers	JMZ - 0105
8:30–10 a.m.	FJ	Undergraduate Research and Capstone Projects II	ASY - 2203
8:30–10:10 a.m.	FB	K-12 PER II	SSU - Charles Carroll A
8:30–10:10 a.m.	FF	Publishing Physics Textbooks: Old and New	SSU - Pyon Su
8:30–10:10 a.m.	FD	ADVANCE Grants: Increasing the Participation of Women in Physics	SSU - Juan Ramon Jimenez
8:30–10:30 a.m.	FA	Effecting Change Using PER	SSU - Benjamin Banneker B
8:30–10:30 a.m.	FC	MOOCs Go to High School	SSU - Charles Carroll B
8:40–10:30 a.m.	FE	PER: Exploring Problem Solving Approaches and Skills	SSU - Margaret Brent A/B
8:30–10:20 a.m.	FH	Soft Matter Labs	SSU - Prince George's
10–10:20 a.m.	FL	Innovative Engagement Strategies for Lecture Classes	SSU - Benjamin Banneker A
10:30–11:30 a.m.	**Awards**	**Millikan Medal – Robert A. Morse**	**SSU - Hoff Theater**
11:30 a.m.–12:45 p.m.		Membership and Benefits Committee	SSU - Pyon Su
11:30 a.m.–12:45 p.m.		Committee on SI Units and Metric Education	SSU - Charles Carroll A
11:30 a.m.–1 p.m.	TOP08	Physics On the Road: An Introduction	SSU - Benjamin Banneker A
11:30 a.m.–1 p.m.	TOP09	PERTG Town Hall	SSU - Benjamin Banneker B
11:30 a.m.–1 p.m.	TOP10	iOS and Android App Show	SSU - Juan Ramon Jimenez
11:30 a.m.–1 p.m.	TOP11	Proposed AAPT Governance Changes II	SSU - Charles Carroll B
12–1 p.m.		Tour of Physical Sciences Complex	PSC
1–2:30 p.m.		Post-Deadline Poster Session	SSU - Grand Ballroom Lounge
1–3 p.m.	GF	Retention and Representation Programs	SSU - Charles Carroll A
1–3 p.m.	GG	Sustaining Thriving Physics Grad. Programs by Embracing Challenges in 21st Century	JMZ - 0220
1–3 p.m.	GI	Teaching and Learning in Upper Division Physics: Optics	SSU - Prince George's
1–3 p.m.	GJ	Post-Deadline I (Papers)	JMZ - 0105
1–3 p.m.	GK	Post-Deadline II (Papers)	SSU - Pyon Su
1–3 p.m.	GL	Post-Deadline III (Papers)	PHY - 1204
1–3 p.m.	GM	Post-Deadline IV (Papers)	PHY - 1201
1:10–2:40 p.m.	GC	Introductory Courses II	SSU - Margaret Brent A/B
1:30–2:40 p.m.	GH	Teacher, TA, and Faculty Training and Development	SSU - Charles Carroll B
1:30–2:40 p.m.	GD	PER: Diverse Investigations III	SSU - Benjamin Banneker B
1:30–3 p.m.	GA	Best Practices for Video Use and Online Education	SSU - Benjamin Banneker A
1:30–3 p.m.	GE	Panel: Professional Skills for Graduate Students	SSU - Juan Ramon Jimenez
3–5:30 p.m.		AAPT Executive Board III	Marriott - 2110/2111
3–3:30 p.m.		Great Book Give Away	SSU - Foyer
3–4 p.m.	PERC	PERC Bridging Session	SSU - Hoff Theater
3:30–4:15 p.m.		Nominating Committee II	Marriott - 0101
5–8:30 p.m.		PER Banquet and PER Conference	Marriott - Potomac Ballroom

First time at an AAPT meeting?

Welcome to the 2015 AAPT Summer Meeting in College Park! Everyone at AAPT hopes you fulfill all the goals you have for attending this meeting. To help you plan your meeting activities, the following information and suggestions have been developed.

- Being at your first National Meeting can be a lonely experience if you don't know anyone. AAPT members are friendly people, so do not hesitate to introduce yourself to others in sessions and in the hallways. It is fun and rewarding to establish a network of other physics teachers with whom you can talk and share experiences. This is especially true during lunch and dinner.

- Area Committee meetings are not only for members of the committee, but also for friends of the committee. You are welcome to attend any Area Committee meeting. You should be able to find one or two committees that match your interests. Their meeting times are listed on page 20 in this guide. Area Committee meetings are often relatively small and are a great place to meet other people with interests similar to yours.

- Be sure to attend the First Timers' Breakfast from 7–8 a.m. on Monday in the Stamp Student Union, Prince George's Room. It is a wonderful way to learn more about the meeting and about AAPT.

- You can still sign up for the annual 5K Fun Run/Walk on Tuesday 7–8 a.m.

- Awards and other plenary sessions have distinguished speakers and are especially recommended. Invited speakers are experts in their fields and will have half an hour or more to discuss their subjects in some depth. Posters will be up all day and presenters will be available during the times indicated in the schedule. Contributed papers summarize work the presenters have been doing. You are encouraged to talk to presenters at the poster sessions or after the contributed paper sessions to gain more information about topics of interest to you. Informal discussion among those interested in the announced topic typically will follow a panel presentation, and topical discussions are entirely devoted to such discussions.

- Be sure to make time to visit the exhibits in the Exhibit Hall. This is a great place to learn what textbooks and equipment are available in physics education.

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

Dwain Desbien
Estrella Mountain Community College, Avondale, AZ

Introductory Physics: What We Teach, How We Teach It, and What We Should Be Doing!

Monday, July 27

10:30 a.m. –12 p.m.

SSU - Hoff Theater

Dwain Desbien receives the 2015 David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching in recognition of his contributions to undergraduate physics teaching and extraordinary accomplishments in communicating the excitement of physics to students. John Wiley & Sons is the principal source of funding for this award, through its donation to AAPT.

Desbien earned a BA in Physics at Grinnell College and his MS in Physics at the University of Kansas. While at the University of Kansas he began his teaching career as a Teaching Assistant and did research in nuclear physics. He taught at Highland Community College, Highland, KS, before beginning his PhD work at Arizona State University. While working on his PhD at ASU, Desbien taught at Chandler-Gilbert Community College where much of his data was collected for his dissertation. While working on his degree, he was a teaching/research assistant in Physics Education Research. Desbien was hired by Estrella Mountain Community College to start their physics program in 2001 and completed his PhD in 2002. As a physics professor and former division chair, he has built a premier physics teaching program, recognized as one of the 10 best two-year college programs in the United States by the Spin-Up/TYC Project.

Since 2006 he has served as Co-PI on the Two-Year College Physics Workshop Project, helping conduct three-day intensive workshops around the U.S. At many of these workshops, he was one of the main presenters of modeling discourse management, MBL, simulations, computational modeling, and other student-tested curricular ideas and activities that have worked successfully in introductory physics at many schools and colleges. He has been one of the three primary presenters at the Two-Year College New Faculty Training Experiences, and led a series of workshops dedicated to developing new laboratory activities for introductory physics.

Building on the accomplishments of Malcolm Wells, who revolutionized high school physics teaching with his contributions to Modeling Instruction, Desbien has creatively and tirelessly worked to encourage students to take charge of their own learning. He developed new techniques to achieve that goal, such as Modeling Discourse Management, Circle Whiteboarding, and Seeding. His skill in implementing such techniques has made him a very effective physics teacher. His continued efforts to help others develop these skills have made a major contribution to physics education. His students are enthusiastic in their praise of his selfless service, support, and creative engineering of learning experiences that empower them to learn in their unique life circumstances.

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 Pre-College Physics Teaching

Gillian Winters
Smithtown Central School District
Smithtown, NY

Carpe Diem. Seize the Opportunity!

Monday, July 27

10:30 a.m. –12 p.m.

SSU - Hoff Theater

The 2015 Paul Zitzewitz Excellence in Pre-College Physics Teaching Award winner is Gillian Winters, a New York State Master Teacher and high school physics teacher from St. James, NY. 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.

Winters earned her BS and MS in Physics at the McGill University in Montreal. Her PhD in Physics is from the University of Delaware. Following coursework for certification for Secondary Education, Physics and General Science she began her career as a physics teacher at Sachem Central School District in Holbrook, NY, where she taught Regents Physics and AP-B Physics, and led the Science Research Program. In 2005 she moved to the Smithtown Central School District in Smithtown, NY, where she teaches Regents, AP-B or AP-1 Physics, and AP-C Physics with Calculus.

Winters is a master of incorporating practical applications to physics content instruction. She routinely goes the extra mile for her students and for physics. When a dwindling student population threatened the District's ability to offer AP Physics with Calculus she volunteered to teach a long-distance course that puts her at Smithtown East on A days with the lesson televised to Smithtown West. On B days the pattern is reversed. Her students are exposed to a variety of rich academic experiences. For example, she conducts a Particle Physics MasterClass as an outreach program of CERN. Her students gather a few afternoons to learn how to analyze data prior to conferencing with students in other countries to participate in a discussion moderated by a physicist from CERN.

She is active in the Women in Science and Engineering workshops at Stony Brook University, the Teslamania, a physics Demonstration competition, and the CERN Physics MasterClass. Her colleagues indicate that she was chosen to be a New York State Master Teacher because of her dedication to students. In this role she is now working with her younger peers, mentoring them in the art of physics teaching.

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.

Klopsteg Memorial Lecture Award

David A. Weintraub of the Vanderbilt University Department of Physics and Astronomy is the 2015 recipient of the Klopsteg Memorial Lecture Award.

Weintraub earned his BS at Yale, and both his MS and PhD from the University of California, Los Angeles. He was a postdoctoral research associate at the University of Florida before joining the Astronomy faculty of Vanderbilt University in 1991.

Weintraub excels at presenting science to the public in an entertaining and comprehensible manner, as well as exploring the humanistic aspects of science with his students. He is the author of three popular astronomy books: *Is Pluto a Planet*? (Princeton University Press 2006), *How Old is the Universe*? (Princeton University Press 2011), and *Religions and Extraterrestrial Life: How Will We Deal With It*? (Springer Praxis Books 2014). All three of these books successfully convey the excitement of astronomy to the general public. He has presented numerous public lectures in connection with these books.

A further example of Weintraub's interest in the communication of science to the general public is his role, for the past nine years, as director of the Communication of Science & Technology Program at Vanderbilt. He leads an extremely successful undergraduate program designed to teach students to present scientific ideas in an accessible way to the general public.

His own research area is the study of debris disks around stars, but Weintraub also has a deep interest in the impact of science on human society. He has taught an honors seminar on "The Tangled Web of Astronomy and Religion," covering such topics as cosmology and the trial of Galileo. He regularly teaches a related course "Theories of the Universe," which explores the overlap between astronomy, religion, and philosophy throughout the ages. Another illustration of his wide-ranging intellectual interests is his seminar on "Black Holes and Science Fiction."

His longstanding interest in the impact of science on human society, combined with his excellent popular science writing, make him an ideal candidate for the Klopsteg Memorial Award.

***The Klopsteg Memorial Lecture Award** is named for Paul E. Klopsteg, a principal founder, a former AAPT President, and a long-time member of AAPT, and 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.*

David A. Weintraub
Vanderbilt University
Department of Physics and Astronomy
Nashville, TN

Exoplanets: The Pace of Discovery and the Potential Impact on Humanity

Tuesday, July 28

10:45 a.m.–12 p.m.

SSU - Hoff Theater

Robert A. Millikan Medal

Robert A. Morse will receive the 2015 Robert A. Millikan Medal. This award recognizes educators who have made notable and creative contributions to the teaching of physics.

Morse is co-chair of the AP Physics 1 Development Committee and assistant editor of the Davidson AP Physics EdX project. He got his BA in physics at Cornell University, his MEd in Science Education at Boston University, and his PhD in Science Education at the University of Maryland, College Park, MD. He started his career as a physics educator in 1967 as a physics teaching assistant at Massachusetts Institute of Technology. He started teaching high school physics at Masconomet Regional High School in Topsfield, MA, where he taught physics, honors physics, AP Physics, Applied Physics, Electronics, Physical Science, and Stagecraft and Lighting.

In 1982 he joined the staff of St. Albans School in Washington, DC, teaching Physics and AP Physics C. He also served as Science Department Chair and Technology Committee Chair. He was trained as an AAPT Physics Teaching Resource Agent in 1985 and has presented or hosted workshops locally and nationally.

A Life Member of AAPT, Morse has served on the committees on Physics in High Schools, Laboratories, and History and Philosophy of Physics. He is a current member of the AAPT PTRA Oversight Committee and served on the Next Generation Science Standards Review Panel.

He has made many creative contributions to physics education: technology-infused curricula in his own high school classes, curricular modules on electrostatics and Newton's laws distributed by AAPT/PTRA for a broader audience of students and teachers, serving as "master teacher for master teachers" in the early PTRA program, offering innovative workshops for instructors at AAPT meetings, and working over the past 14 years on multiple committees to play a lead role in revising the Advanced Placement (AP) Physics B curriculum and exams. To all these endeavors, he brings passion, inquisitiveness, creativity, and deep understanding of how students learn.

***The Robert A Millikan Medal**, established in 1962, recognizes teachers who have made notable and creative contributions to the teaching of physics. The recipient is asked to make a presentation at the Ceremonial Session of an AAPT Summer Meeting. A monetary award, The Millikan Medal, an Award Certificate, and travel expenses to the meeting are presented to the recipient.*

Robert A. Morse
St. Albans School
Washington, DC

Facets of Physics Teaching – Pedagogical Engineering in the High School Classroom

Wednesday, July 29

10:30 a.m. –12 p.m.

SSU - Hoff Theater

2015 Homer L. Dodge Citations for Distinguished Service to AAPT

Monday, July 27, 10:30 a.m.–12 p.m. • SSU - Hoff Theater

Kathleen Harper

Kathleen A. Harper

Kathleen A. Harper, Senior Lecturer, Engineering Education Innovation Center, The Ohio State University, is currently serving as chair of the AAPT Nominating Committee and as Section Representative for the Southern Ohio Section of AAPT. She earned her BSE in Electrical Engineering and Applied Physics and her MS in Physics from Case Western Reserve University in Cleveland. Her PhD from The Ohio State University was in physics with emphasis in physics education research.

Her AAPT service includes the Nominating Committee, including working as chair this past year. She is a member of the Membership and Benefits Committee and has served on the Committee on Research in Physics Education. A member since 1994, Harper has been the Southern Ohio Section Representative since 2007. (More at: http://www.aapt.org/aboutaapt/pressreleases/2015-Dodge-Citation-presented-to-Kathleen-Harper.cfm.)

Jill Marshall

Jill Marshall

Jill Marshall, University of Texas, Austin, Department of Physics, is recognized for her work at the section and national level of AAPT. She has been active in the Texas Section of AAPT for many years. She was elected to the Texas presidential chain in 2004 and served from 2005 through 2008. During those four years, she led the section with distinction solidifying its relationship with the Texas Science Teachers Association and their large CAST conference. She also helped keep the section meetings joint with the Texas Section APS and SPS Zone 13. Prior to working in Texas, she was an active member of the Idaho-Utah Section of AAPT, serving as President, 1999-00. At the national level her service includes: AAPT Past President (2013), Program Chair of the 2011 Winter and Summer Meetings, National Nominating Committee 2005-06, Committee on Women in Physics 2006-09, presenter and session organizer at national meetings 1998-to present. (More at: http://www.aapt.org/aboutaapt/pressreleases/SM15HLDCJillMarshall.cfm)

Marie Plumb

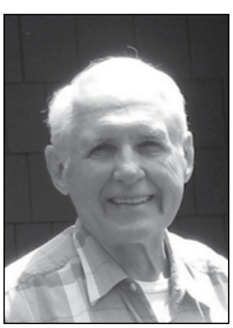
Marie Plumb

Marie Plumb, Professor of Physics (Retired) at Jamestown Community College, Jamestown, NY, has served as a member of Steering Committee and Co-chair of a national meeting for the Two Year Colleges in the 21st Century Project; PI and co-PI on several NSF Grants; instituted an ongoing outreach program to bring hands-on science activities to a local elementary school; served as reviewer of grants for NSF; participated in PEPTYC program at Texas A&M; and hosted TYC workshops. She served on the Statistical Research Committee of the American Institute of Physics (2011-2015) and currently serves on the Executive Board of the Dresser Rand Challenger Center, a member of the National Challenger Center Association. She was recognized with the Outstanding Physics Graduate Student Award (1990), Outstanding Educator Award (2000), Presidents Award for Excellence in Teaching (2003), and New York State Chancellor's Award for Excellence (2004). (More at: http://www.aapt.org/aboutaapt/pressreleases/Marie-Plumb-to-Receive-the-2015-Homer-Dodge-Citation-for-Distinguished-Service-to-AAPT.cfm)

Scott Schultz

Scott Schultz

Scott Schultz, Science Division Chair and Professor of Physics at Delta College, University Center, MI, joined AAPT in 1993, while in grad school at North Carolina State University. He has served on the AAPT Nominating Committee twice, once as chair, as well as on the Committee on Educational Technology, and the Committees on Physics in Two-Year Colleges. He earned his BA with a double major in physics and secondary education at Canisius College. His MS in physics with a science education minor was earned at North Carolina State University. He studied graduate courses in quantum optics and physics education at Texas A&M University, completing the PEPTYC program. Schultz has taught physics at Jamestown Community College, Ravenscroft High School and has been at Delta College for 17 years. He has served the AAPT physics education community in many ways over the years. (More at: http://www.aapt.org/aboutaapt/pressreleases/Scott-Schultz-2015-Dodge-Citation.cfm)



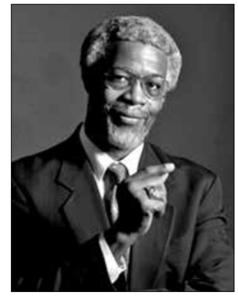
Albert Thompson

Albert Thompson

Albert Thompson earned his BA in Physics with a minor in Education at The Colorado College. His MA in Secondary School Administration was earned at the University of Colorado at Boulder, and his EdD in K-12 School Administration at the University of Northern Colorado. He began PTRA training in 1992 and continued in the program through 2010. He retired as a Physics, Physical Science, Astronomy, and Global Science teacher at Ponderosa High School in Parker, CO. Thompson, an emeritus member, first joined AAPT during 1961-68 when AAPT recognized him for "An Outstanding Program in Physics" at Cherry Creek High School in Englewood, CO, then rejoined in 1984 after returning to teaching physics. He has been actively involved in the Colorado-Wyoming Section and is the founding Coordinator of the AAPT eMentor Program. Thompson came to the AAPT Executive Officer, Warren Hein, in the summer of 2008 with the idea of AAPT starting an electronic mentoring service for new physics teachers and consented to be the first director of AAPT's e-Mentor project. h(More at: http://www.aapt.org/aboutaapt/pressreleases/Albert-Thompson-Dodge-Citation.cfm)

Is SUSY the Guardian of Our Reality from Oblivion?

Monday, July 27, 7:30–8:30 p.m. • SSU - Hoff Theater



S. James Gates Jr.
University of Maryland
College Park, MD

Jim Gates is University System Regents Professor, Distinguished University Professor, the John S. Toll Professor of Physics, and the Center for Particle & String Theory Director, University of Maryland, College Park, MD. He received two BS degrees (mathematics & physics) in 1973 and a PhD, all from Massachusetts Institute of Technology, the latter in 1977. His doctoral thesis was the first thesis at MIT to deal with supersymmetry. He also completed postgraduate studies at both Harvard University and the California Institute of Technology (CalTech). Gates serves on the U.S. President's Council of Advisors on Science and Technology (PCAST) and the Maryland State Board of Education (MD-BoE). He is known for his work on supersymmetry, supergravity, and superstring theory. In 1984, working with M.T. Grisaru, M. Rocek, W. Siegel, Gates co-authored *Superspace,* the first comprehensive book on the topic of supersymmetry. In 2006, he released, the book *L'arte della Fisica* (*The Art of Physics*), and has authored over 200 scientific publications.

AAPT Fellows Recognition

Tuesday, July 28, 10:45 a.m.–12 p.m. • SSU - Hoff Theater

The criterion for selection of Fellows is exceptional contribution to AAPT's mission, to enhance the understanding and appreciation of physics through teaching. Fellowship is a distinct honor signifying recognition by one's professional peers.

- *Frank Cascarano*
- *Anthony Escuadro*
- *Paul (Joe) Heafner*
- *William T. Waggoner*
- *Paul Williams*

AIP Andrew Gemant Award to *Ainissa Ramirez*

Our Sputnik Moment in STEM Education

Tuesday, July 28, 4–5 p.m. • SSU - Hoff Theater

Ainissa G. Ramirez

Ainissa G. Ramirez is a science evangelist who is passionate about getting the general public excited about science. She co-authored *Newton's Football: The Science Behind America's Game* (Random House); and authored *Save Our Science: How to Inspire a New Generation of Scientists* (TED Books). Before taking on the call to improve the public's understanding of science, she was an Associate Professor of Mechanical Engineering & Materials Science at Yale University. *Technology Review,* the magazine of the Massachusetts Institute of Technology (MIT), named her as one of the world's 100 Top Young Innovators for her contributions to transforming technology. She has been profiled in *The New York Times*, *Fortune Magazine*, CBS News, Inside Edition, Fox News, CNN, NPR, ESPN, *Time Magazine* as well as scientific magazines (*Scientific American* and *Discover Magazine*). Dr. Ramirez received her training in materials science and engineering from Brown University (ScB) and Stanford University (PhD). Prior to being on the faculty at Yale, she was a research scientist at Bell Laboratories, Lucent Technologies, in Murray Hill, NJ, were she did award-winning research. She has authored more than 50 technical papers, holds six patents, and has presented her work worldwide. She now focuses her energies on making science fun, and gave an impassioned called to action at TED on the importance of understanding science, technology, engineering, and math (STEM), which generated widespread enthusiasm. At Yale, she was the director of the award-winning science lecture series for children called Science Saturdays and hosted two popular-science video series called Material Marvels and Science Xplained.

Committee Meetings

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

Saturday, July 25

Nominating Committee I (closed)	6–7:15 p.m.	Marriott - 0101
Executive Board	6–9 p.m.	Marriott - 2110/2111

Sunday, July 26

Publications Committee	8–10 a.m.	Marriott - 0101
Meetings Committee	8–10 a.m.	Marriott - 0105
Resource Letters Committee	10:30–1:30	Marriott - 0102
Executive Board II	10:30–4 p.m.	Marriott - 2110/2111
Programs Committee I	5:30–6:30 p.m.	SSU - Charles Carroll A
Section Representatives / Officers	5:30–8 p.m.	SSU - Charles Carroll B
High School Share-a-Thon*	6–8 p.m.	SSU - B. Banneker A
Committee on Interests of Senior Physicists*	6:30–7:45 p.m.	SSU - B. Banneker B
Committee on Teacher Preparation*	6:30–7:45 p.m.	SSU - Margaret Brent A
Committee on Physics in Undergraduate Ed.*	6:30–7:45 p.m.	SSU - Charles Carroll A
Committee on Women in Physics*	6:30–7:45 p.m.	SSU - Margaret Brent B
ALPHA Committee	6:30–7:45 p.m.	SSU - J. Ramon Jimenez
Executive Programs Committee	6:30–7:45 p.m.	SSU - Pyon Su

Monday, July 27

Committee on Educational Technologies*	7–8:15 a.m.	SSU - B. Banneker A
Committee on Graduate Education in Physics*	7–8:15 a.m.	SSU - B. Banneker B
Committee on Science Education for Public*	7–8:15 a.m.	SSU - Charles Carroll A
Committee on Diversity in Physics*	7–8:15 a.m.	SSU - Charles Carroll B
Review Board	12–1:15 p.m.	SSU - Margaret Brent A
Physics Bowl Advisory Committee	12–1:15 p.m.	SSU - Crossland
Committee on Apparatus*	6:15–7:30 p.m.	SSU - Charles Carroll A
Committee on Physics in High Schools*	6:15–7:30 p.m.	SSU - Atrium
Committee on International Physics Education*	6:15–7:30 p.m.	SSU - Margaret Brent A
Committee on Space Science and Astronomy*	6:15–7:30 p.m.	SSU - Crossland
Committee on Professional Concerns*	6:15–7:30 p.m.	SSU - Pyon Su
PTRA Advisory Committee	8:30–10 p.m.	SSU - B. Banneker A

Tuesday, July 28

Venture/Bauder Endowment Committee	7–8 a.m.	SSU - Margaret Brent A
COGS (Governance Structure)	7–8 a.m.	SSU - Margaret Bent B
Committee on Physics in Two-Year Colleges*	12–1:15 p.m.	SSU - B. Banneker A
Committee on Laboratories*	12–1:15 p.m.	PHY - 1204
Committee on History & Philosophy in Physics*	12–1:15 p.m.	SSU - B. Banneker B
Committee on Physics in Pre-High School Ed.*	12–1:15 p.m.	SSU - Charles Carroll A
Committee on Research in Physics Education*	12–1:15 p.m.	SSU - Charles Carroll B
PIRA Committee	12–1:15 p.m.	PHY - 1201

Wednesday, July 29

Programs Committee II	7–8:30 a.m.	Marriott - 0105
Awards Committee	7–8:30 a.m.	Marriott - 0101
Finance Committee	7:30–8:30 a.m.	Marriott - 2111/2110
Membership and Benefits Committee	11:30–12:45	SSU - Pyon Su
Committee on SI Units and Metric Education*	11:30–12:45.	SSU - Charles Carroll A
Nominating Committee II (Closed)	3:30–4:15 p.m.	Marriott - 0101
Executive Board III	3–5:30 p.m.	Marriott - 2110/2111

Free Commercial Workshops

CW01: The Expert TA: Closing the Gap Between Homework and Test Scores

Location: SSU - Juan Ramon Jimenez
Date: Monday, July 27
Time: 12–1 p.m.
Sponsor: The Expert TA

Leader: Jeremy Morton

The delta between students' homework grades and test scores is a concern we share with you. In order to study this, Expert TA entered into the arena of "Big Data" with our new Analytics tool. We used this to do an intense analysis of data from 125 classes from the 2013-2014 AY. Individual course reports are provided to instructors and we internally facilitated a cross-reference of all reports. We identify that major factors causing these gaps are: access to immediate and meaningful feedback, practice on symbolic questions, and a minimized ability to find problem solutions online. Knowing this, we have worked to develop the largest available library of "symbolic" questions and we use Analytics to data mine every incorrect answer every submitted, in order to continually improve our feedback for these questions. We have also put in place very effective strategies to guard our problem solutions. The ultimate goal is to keep students focused on the physics; and then as they are working problems to provide them with meaningful, Socratic feedback that helps resolve misconceptions. Please join us and learn how other instructors are using this resource to reduce cost to students, increase academic integrity, and improve overall outcomes.

CW02: Physics with PASCO Scientific, Featuring PASCO Capstone™, the Ultimate Data Collection and Analysis Software for Physics

Location: SSU - Margaret Brent A
Date: Monday, July 27
Time: 8–9 a.m.
Sponsor: PASCO scientific

Leader: Brett Sackett

Get hands-on with the most sophisticated and flexible Physics software available today, PASCO Capstone, with advanced Physics analysis features including video analysis. See how using PASCO probeware, software, and equipment will enhance your physics demonstrations and labs. Enter to win a copy of PASCO Capstone!

CW02-B: Physics with PASCO Scientific, Featuring PASCO Capstone™, the Ultimate Data Collection and Analysis Software for Physics

Location: SSU - Margaret Brent A
Date: Monday, July 27
Time: 9–10 a.m.
Sponsor: PASCO scientific

Leader: Brett Sackett

Get hands-on with the most sophisticated and flexible Physics software available today, PASCO Capstone, with advanced Physics analysis features including video analysis. See how using PASCO probeware, software, and equipment will enhance your physics demonstrations and labs. Enter to win a copy of PASCO Capstone!

CW03: WebAssign: Enrich Your Physics Course with WebAssign Additional Resources

Location: SSU - Margaret Bent B
Date: Monday, July 27
Time: 1:30–2:30 p.m.
Sponsor: WebAssign

Leader: Matt Kohlmyer

Since 1997, WebAssign has been the online homework and assessment system of choice for introductory physics lecture courses. Many veteran instructors already know that WebAssign supports over 150 introductory physics textbooks with precoded, assignable questions and advanced learning tools. WebAssign offers even more great resources for physics instruction, many of which can be adopted to supplement publisher offerings for no additional charge. In this presentation, we will focus on the wide array of WebAssign resources you can use to enrich your physics course. These include original question collections with feedback, solutions, and tutorials paired to some of the most popular textbooks; direct measurement videos that help students connect physics to real-world scenarios; conceptual question collections authored by experienced educators and designed around physics education research principles; and lab options that give you a complete low-cost, high-quality course solution. We'll show you how to add any or all of these resources to your WebAssign course. This workshop is intended for current WebAssign users, but newcomers are welcome to join.

CW04: WebAssign 101: Getting Started with WebAssign

Location: SSU - Margaret Brent B
Date: Tuesday, July 28
Time: 9–10 a.m.
Sponsor: WebAssign

Leader: Brad Spiker

This workshop is ideal for new WebAssign users or active users who want to learn more about how to use WebAssign's features to save time, better engage your students, and assess student performance. Join Brad Spiker, WebAssign Implementation Consultant Extraordinaire, for a lively and informative introduction to WebAssign. You'll learn how to create a course, build an assignment, schedule assignments, and get the inside scoop on some of Brad's favorite tips for enriching your physics classroom experience. WebAssign is a powerful online instructional system designed by educators to enhance the teaching and learning experience. You won't want to miss this workshop for a painless way to jumpstart your success with WebAssign.

CW05: Perimeter Institute: Drawing Students into Black Hole Physics

Location: SSU - Prince George's
Date: Monday, July 27
Time: 9–10:30 a.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope and Kevin Donkers

Black holes are arguably the most fascinating objects in the universe— gravitational gluttons even light cannot escape—and they never fail to captivate students. But how can you incorporate black holes into your senior high school physics class? This session will explore the key properties of black holes via inquiry-based student activities, and show how you can apply black hole physics to core curriculum topics including force, gravity, orbits, and escape velocity. Participants will receive a copy of the workshop activities.

CW06: Perimeter Institute: What's New in Physics?

Location: SSU - Atrium
Date: Monday, July 27
Time: 12–1 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope and Kevin Donkers

What's new in physics? From quantum mechanics to cosmology, we'll summarize all the coolest discoveries and highlight what to watch for. This session will explore cutting-edge physics for teachers that are looking for current, real-world science connections in their classroom. We'll discuss the big breakthroughs from this past year that your students are talking about and show you how you can incorporate it in your class.

CW07: Perimeter Institute: The Expanding Universe

Location: SSU - Atrium
Date: Tuesday, July 28
Time: 12–1 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope and Kevin Donkers

Though Edwin Hubble was the first scientist to explain how our universe is expanding, evidence for the expanding universe was actually always there for any stargazer to see—if they knew what to look for. This workshop will empower teachers and students to expand the horizons of their cosmological understanding, and confront some common misconceptions about this incredible phenomenon. Participants will be introduced to hands-on classroom activities that give students the tools to measure and interpret data about the universe's expansion.

CW08: Perimeter Institute: Curved Space-time in the Classroom

Location: SSU - Atrium
Date: Tuesday, July 28
Time: 3–4 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope and Kevin Donkers

We all experience gravity every day, but do we truly understand how it works? Newton pictured gravity as an invisible force, while Einstein posited it as the curving of space-time. How do we know which model to use? In this workshop, we demonstrate how, using just masking tape and balloons, students can attain better understanding of gravitation, and learn how Einstein's model is verified by real-world technologies such as GPS. Designed by educators and Perimeter Institute researchers, this activity engages high school students in the process of building scientific models, and inspires them to think differently about the everyday concepts of gravity, time, and space.

CW09: Sapling Learning: Online Homework with Targeted Instructional Feedback Leads to Improved Student Learning Outcomes

Location: SSU - Margaret Brent B
Date: Monday, July 27
Time: 9–10 a.m.
Sponsor: Sapling Learning

Leader: Carl Knutson, PhD

A primary goal of higher education STEM instructors is to teach students how to solve complex problems. Traditionally, out-of-classroom homework assignments have been used as a tool to accomplish this goal. However, a distinct disadvantage of out-of-classroom assignments is the lack of feedback available to students as problems are completed and mistakes are made. As a result, instructors have become increasingly interested in using online homework to provide immediate feedback to their students. While many homework systems offer similar advantages over traditional paper assignment, such as immediate feedback, online grading, and student progress statistics, few offer targeted instructional feedback that is proven to help students master the material and succeed in the classroom. This presentation will further discuss the benefits of using an online homework system with surrogate tutoring feedback.

CW10: It's About Time: Active Physics: The Leading Project-based High School Physics Program Capturing the Essence of the NGSS and STEM – Learn About New Support Resources

Location: SSU - Juan Ramon Jimenez
Date: Monday, July 27
Time: 9:30–10:30 a.m.
Sponsor: It's About Time

Leader: Arthur Eisenkraft, PhD

Learn from Dr. Arthur Eisenkraft how you can implement STEM and NGSS in your Physics and/or Physics First classroom. Gain an understanding of the benefits of the embedded engineering design cycle. Learn how physicists, teachers, and science educators collaborated to design this innovative, NSF-funded and research-based, project-driven curriculum that has demonstrated significant success to engage ALL students AND increase student performance. New resources include an Active Physics 24/7 online support site for teachers.

CW11: Physics2000 Workshop

Location: SSU - Margaret Brent B
Date: Monday, July 27
Time: 12–1 p.m.
Sponsor: Physics2000

Leader: Elisha Huggins

The purpose of the two Physics2000 workshops is to look at ways to bring the physics of general relativity into introductory physics and why we should do this. In the first workshop, we will look at the Pound Rebka experiment from the point of view of Einstein's equivalence principle, where we see that the uniform gravitational field inside an elevator shaft at Harvard University can either expand or contract space depending upon the observer's point of view. This analysis allows us to compare the strength of the earth's gravitational field with the strength of the repulsive gravitational field created by dark energy. The gravitational field at Harvard is thirteen billion times stronger.

CW12: It's About Time: What's New in Next Generation Physics and Everyday Thinking?

Location: SSU - Margaret Brent A
Date: Tuesday July 28
Time: 9–10 a.m.
Sponsor: It's About Time

Leaders: Fred Goldberg and Steve Robinson

PET, PSET and related curricula have been extensively revised to make them more aligned with the Next Generation Science Standards and more flexible for implementation in a variety of courses and learning environments. Next Gen PET consists of five separate modules: four focusing on the NGSS physical science core ideas (energy, force and motion, waves, and properties of matter), and one focusing on building models of magnetism and static electricity. Each module includes two engineering design activities. There is also an extensive set of optional teaching and learning activities associated with each module that help students make explicit connections between teaching, learning, and the NGSS. Almost every activity has an online tutorial-style homework extension that includes a quiz that can be scored by the institution's learning management system. There are two distinct versions of each module: one for use in small class environments, where the focus is almost entirely on small group laboratory work and discussion (like PET or PSET); and a second for use in lecture-style classes (either large or small enrollment), where opportunities for laboratory work are limited.

CW13: Physics2000 Workshop

Location: SSU - Prince George's
Date: Tuesday July 28
Time: 12–1 p.m.
Sponsor: Physics2000

Leader: Elisha Huggins

The purpose of the two Physics2000 workshops is to look at ways to bring the physics of general relativity into introductory physics and why we should do this. In the second workshop, we will ask why the accelerator at CERN cannot push a proton quite as fast as the speed of light, while the very weak repulsive field of dark energy can move entire galaxies away from us faster than the speed of light. We will also take a brief look at the nature of curved space-time that we see in the Harvard elevator shaft.

CW14: Experiments and Data Collection with Vernier

Location: SSU - Juan Ramon Jimenez
Date: Tuesday July 28
Time: 1–3 p.m.
Sponsor: Vernier Software & Technology

Leaders: David Vernier, Fran Poodry, and John Gastineau

Attend this hands-on workshop to learn about physics experiments and data collection with Vernier. We will start with an interactive presentation to show you how Vernier data collection works on a variety of platforms, including Chromebooks. Then you may explore a variety of physics apparatus using your own device or one of ours.

- Use the LabQuest 2 interface as a stand-alone device or as an interface to a computer or Chromebook.
- Collect and analyze data using an iPad, Android tablet, or Chromebook—ours or yours.
- Test the Vernier Motion Encoder System, and see just how good dynamics cart data can be.
- Try out the new Vernier Structures and Materials Tester with our sample beams and bridges.
- Generate electricity and explore electromagnetism with the simpleGEN generator kit.
- Explore the new Vernier Circuit Board 2
- Do video analysis using Vernier Video Physics on an iPad.
- Experiment with Vernier Sensors connected to Arduino-compatible micro controller boards.

CW15: Science First: Saving Valuable Lesson Preparation Time by Using curricuLAB

Location: SSU - Prince George's
Date: Tuesday July 28
Time: 9:30–10:30 a.m.
Sponsor: Science First

Leader: Ruben Manuel Briseno

Digital education 3.0 with curricuLAB from PHYWE is a new management and experimentation platform. It saves up to 40% of your valuable time by streamlining planning, preparing, and receiving science lessons. CurricuLAB manages content and customizable curriculum compliance. We will discuss how this tool will create the following benefits:

- time saving, which leads to higher quality of teaching, better results and stronger motivation,
- easier and more efficient organization and administration, which reduces stress levels and allows for a higher focus on the lessons,
- integration of tablets and smartphones in the lessons, which improves student motivation and enhances media competence,
- have more fun and achieve your objective faster.

The workshop will show how CurricuLAB supports you with all your requirements in terms of management, didactic background, integration of digital media and teaching concepts.

AAPT Journals

Booth #305
One Physics Ellipse
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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.

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Welcome to Maryland! Join us at the AAPT booth and spin the wheel for your chance to win some awesome prizes! We will have a large selection of educational resources, for free and to purchase, to use in your classroom. Check out the latest AAPT-branded merchandise today!

American Physical Society

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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.

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The EASYPET is the new Educational tool in the CAEN Catalog and it strengthens CAEN to provide advanced instrumentation for Modern Physics teaching. Developed together with University of Aveiro, the EASYPET is a compact Arduino-based PET station, thanks to which it is possible to learn the principle of operation of Positron Emission Tomography and the secrets behind this technique. The product includes a dedicated MATLAB Control & Analysis SW, allowing for a simple acquisition and lab notes preparation.

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Essential Physics, from Ergopedia, is a high school STEM physics program that includes an extraordinary e-Book, matching print textbook, and a coordinated set of powerful, wirelessly connected lab equipment. Essential Physics interactivity makes rigorous physics concepts accessible to all levels. Ergopedia also offers a full suite of physics equipment modules, suitable for high school and middle school.

The Expert TA

Booth #200
624 South Boston Avenue
Suite 220
Tulsa, OK 74119
918-949-4190
Cindy@theexpertta.com
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 200 for a demonstration.

GradSchoolShopper

Booth #214
One Physics Ellipse
College Park, Md 20740
301-209-3023
info@aip.org

GSS features the profiles of several hundred graduate programs with comparative information on degrees offered, admissions, financial aid, housing, degree requirements, department and faculty research specialties, facilities, notable alumni, etc. The Graduate Programs in Physics, Astronomy, and Related Fields is its print companion. The book is celebrating its 50th Anniversary this year.

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Klinger Educational will be exhibiting the LEYBOLD X-ray machine and Tomography module. Both now have an available locking, storage drawer that fits directly under the main units. Also featured is the HD upgrade for the Goniometer, enabling a 10X higher resolution achieved through narrower apertures and software. X-rays are detected with an End-window Counter or an Energy Detector. In addition we will have a Diode pumped Nd:YAG Laser with Frequency Doubling to demonstrate optical pumping, second harmonic generation and spectroscopy.

National Science Foundation

Booth #204
4201 Wilson Blvd.
Arlington, VA 22230
703-292-5111
info@nsf.gov
www.nsf.gov

The National Science Foundation booth will provide information about and connections to numerous NSF programs of interest to those teaching physics and astronomy. These include the Division of Undergraduate Education's IUSE (Improving Undergraduate STEM Education) program, the DUE S-STEM (NSF Scholarships in Science, Technology, Engineering, and Mathematics) program, the Division of Physics' Integrative Activities in Physics program, and other programs. Additional pointers to information and contacts will also be provided on REU (Research Experiences for Undergraduates) opportunities, the HBCU-UP program, engineering programs, and teacher preparation programs. A schedule will be posted detailing the availability of NSF program officers representing each interest.

OpenStax College

Booth #319, 321
6100 Main Street
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713-348-2965
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OpenStax College is a nonprofit organization committed to improving student access to quality learning materials. An initiative of Rice University and made possible through the generous support of philanthropic foundations, OpenStax College provides free textbooks, developed and peer-reviewed by educators to ensure they are readable, accurate and meet the scope and sequence requirements of your course.

Optical Society of America

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The Optical Society (OSA) is the leading professional society in optics and photonics, home to accomplished science, engineering, and business leaders from all over the world. Through world-renowned publications, meetings, and membership programs, OSA provides quality information and inspiring interactions that power achievements in the science of light. Visit the OSA booth to learn more.

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Perimeter Institute for Theoretical Physics

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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.

Physics2000.com

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lish.huggins@dartmouth.edu
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Physics2000.com sold the world's first complete introductory physics text on a CD at the Apple Educational Booth at the 2000 MacWorld in San Francisco. This book begins with special relativity in the first week in order to include current physics in the remainder of the text. In 1998 cosmology was turned upside down with the discovery of the acceleration of the Hubble expansion. We have been working for the last four years on including the new discovery as part of the Physics2000 text. Our two workshops this summer will show how far we have gotten.

PhysTEC

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Quantum Design

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College Park, MD 20740
301-209-3008
lquijada@aip.org
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).

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Monday, July 27 – Session Schedule

Poster Session 1: 8:30–10 p.m. SSU – Colony Ballroom

Time	JMZ - 0105	JMZ - 0220	ASY - 2203	PHY- 1410	PHY - 1412	SSU Benjamin Banneker A	SSU Benjamin Banneker B	SSU Charles Carroll A	SSU Charles Carroll B	ASY - 2309	SSU Atrium	EGR - 1202	SSU Prince George's	SSU Juan Ramon Jimenez	SSU Hoff Theater
8:30 a.m.	**AA:** Astronomy in the Physics Classroom	**AB:** History of Physics in Other (non-European) Cultures	**AC:** Increasing Access to Grad School	**AD:** Mechanics Modeling Meets New AP Physics I	**AE:** PER: Examining Content Understanding and Reasoning I	**AF:** Photographic Techniques New and Old	**AG:** PIRA Session: Biophysics Demos and Apparatus	**AH:** Teaching Sustainability in the Majors Curriculum	**AI:** Technology in the Physical Science Classroom	**AJ:** Undergraduate Research and Capstone Projects I	**AK:** Innovation & Entrepreneurship				
9:00											**AL:** Make, Play and Learn				
10:30															**Awards Session:** AAPT Teaching Awards; AAPT DSCs
12:00 p.m.						**TOP01:** Solo PER Faculty	**TOP02:** Web Resources for Teaching Astronomy	**TOP03:** Communication Difficulties with Students	**TOP04:** AAPT/APS Joint Task Force on Undergraduate Physics Programs - Update						
1:30	**BC:** Digital Library Resources for Teaching Physical Science	**BD:** First Year Physics Teachers: Insights & Experiences (Panel)	**BA:** Assessment Methods and Issues (Panel)	**BH:** PER Using MOOCs (Panel)	**BG:** PER: Informing Physics Instruction					**BB:** Developing Experimental Skills in the Laboratory	**BF:** PER in the Upper Division I	**BI:** Preparing to Teach Physics to the Next Generation			
2:00						**BJ:** Teaching Physics in an IB School	**BK:** The Art and Science of Teaching	**BE:** LHC in the Classroom	**BL:** What's Working in Other Disciplines: Recruitment and Retention						
4:00	**CC:** Best Practices in Educational Technology I	**CD:** Frontiers in Astronomy	**CE:** Integrating Computational Physics at Intro. Level	**CJ:** PER in the Upper Division II	**CH:** PER: Diverse Investigations I	**CB:** Adapting the TIR Role to Local Contexts	**CG:** Introductory Labs/ Apparatus	**CA:** K-12 PER I	**CM:** Interactive Lecture Demonstrations – What's New?	**CF:** Introductory Courses I	**CI:** PER: Identity and Student Engagement		**CK:** Carnival Knowledge		
5:00									**CL:** Physics Majors and Careers						
6:00						**TOP05:** Physics and Society	**TOP06:** Graduate Student Topical Discussion							**TOP07:** Proposed AAPT Governance Changes I	
7:30															**APS Plenary:** S. James Gates

Building Key: **SSU** = Stamp Student Union **ASY** = Art-Sociology Building **JMZ** = Jimenez Hall **PHY** = John S. Toll Physics Building **EGR** = Glen L. Martin Hall

Tuesday, July 28 – Session Schedule

Poster Session 2: 5–6:30 p.m. SSU – Colony Ballroom

Time	JMZ - 0105	JMZ - 0220	ASY - 2203	PHY- 1410	PHY - 1412	SSU Benjamin Banneker A	SSU Benjamin Banneker B	SSU Charles Carroll A	SSU Charles Carroll B	ASY - 2309	SSU Atrium	SSU Prince George's	SSU Juan Ramon Jimenez	SSU Hoff Theater
8:30 a.m.	**DG:** Improving Students' Problem Solving, Reasoning, and Meta-cognitive Skills	**DH:** Mentoring and Induction of Entering Physics Teachers	**DK:** Succeeding as a Solo Physics Education Researcher (Panel)	**DI:** PER: Diverse Investigations II	**DJ:** Physics Education Policy (Panel)	**DA:** Transitioning to AP 1 & 2 (Panel)	**DB:** Attracting Women to Physics and Girls to Science: What is Working?	**DF:** Interactions of Gender and STEM Environments	**DD:** Co-ordinating Outreach with Community Science Centers	**DL:** Upper Division Undergraduate Courses and Labs	**DC:** Bringing Physics to Life		**DE:** Finding Resources in History of Physics Suitable for Classroom Use	
11:00														**Awards Session:** Klopsteg Memorial Lecture Award; AAPT Fellowships
1:30	**EF:** High School	**EG:** Improving Departmental Climate for Women and Under-represented Ethnic Groups	**EH:** Lab Guidelines Focus Area 1: Constructing Knowledge	**EJ:** Research on ExtraSolar Planets	**EI:** PER: Examining Content Understanding and Reasoning II	**EA:** Al Bartlett Memorial Session	**EB:** Best of European and Middle East Projects	**EC:** Best Practices in Educational Technology II	**ED:** Do you Want to Teach at a Community College?	**EK:** Research on Teamwork	**EL:** Astronomy	**EE:** Effective Practices in Physics Teacher Preparation		
4:00														**Awards:** AIP Gemant Award to Ainissa Ramirez

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Wednesday, July 29 – Session Schedule

Poster Session 3: 1–2:30 p.m. SSU – Grand Ballroom Lounge

	JMZ - 0105	ASY - 2309	PHY - 1201	PHY - 1204	ASY - 2203	SSU Benjamin Banneker A	SSU Benjamin Banneker B	SSU Charles Carroll A	SSU Charles Carroll B	JMZ -0220	SSU Prince George's	SSU Margaret Brent A/B	SSU Juan Ramon Jimenez	SSU Pyon SU	SSU Hoff Theater
8:30 a.m.	**FG:** Re-cruiting, Retaining & Outreach to Underrep. HS Teachers	**FI:** Tesla Coils			**FJ:** Under-graduate Research and Capstone Projects II	**FK:** Astrono-my Education Research	**FA:** Effecting Change Using PER	**FB:** K-12 PER II	**FC:** MOOCs go to High School		**FH:** Soft Matter Labs	**FE:** PER: Exploring Problem Solving Ap-proaches and Skills	**FD:** ADVANCE Grants: Increasing the Participation of Women in Physics	**FF:** Publishing Physics Text-books: Old and New	
9:00															
9:30															
10:00						**FL:** Lect. Classes									
10:30															**Awards Session:** Millikan Medal
11:00															
11:30						**TOP08**: Physics on the Road: An Introduction	**TOP09**: PERTG Town Hall		**TOP11**: Pro-posed AAPT Governance Changes II				**TOP10**: iOS and Android App Show		
12:00 p.m.															
12:30															
1:00	**GJ:** Post-Deadline (Paper)		**GM:** Post-Deadline IV(Paper)	**GL:** Post-Deadline III (Paper)				**GF:** Retention and Repre-sentation Programs		**GG:** Sustain-ing Thriving Physics Graduate Programs	**GI:** Teach-ing and Learning in Upper Divi-sion Physics: Optics	**GC:** Intro-ductory Courses II		**GK:** Post-Deadline II (Paper)	
1:30						**GA:** Best Practices for Video Use and Online Education	**GD**: PER: Diverse Inves-tigations III		**GH:** Teacher, TA, and Fac-ulty Training and Develop-ment				**GE:** Profes-sional Skills for Graduate Students (Panel)		
2:00															
2:30															
3:00															**PERC:** Bridging Session
3:30															
4:00															
4:30															
5:00															
5:30															

Building Key: **SSU** = Stamp Student Union **ASY** = Art-Sociology Building **JMZ** = Jimenez Hall **PHY** = John S. Toll Physics Building **EGR** = Glen L. Martin Hall

AAPT FITNESS CHALLENGE
JULY 26-28, 2015

WHAT DO I NEED TO DO?

- GRAB A PEDOMETER FROM THE AAPT BOOTH -OR- USE YOUR OWN DEVICE
- WEAR IT FROM JULY 26-28
- STOP BY THE AAPT BOOTH BY 3:00PM ON TUESDAY JULY 28
- RECEIVE 1 RAFFLE TICKET FOR EVERY 2,000 STEPS

PRIZES

- UNDER ARMOUR GIFT CARD
- DICK'S SPORTING GOODS GIFT CARD

RAFFLE WILL BE HELD TUESDAY, JULY 28 3:25PM

NO PURCHASE NECESSARY
QUESTIONS: VISIT THE AAPT BOOTH

AAPT PHYSICS EDUCATION

Workshops – Saturday, July 25

All workshops are held at the John S. Toll Physics Building (PHY), or Physical Sciences Complex (PSC)

W01: Tour of the Neils Bohr Archive and Library

Sponsor: Committee on History and Philosophy in Physics
Time: 8 a.m.– 12 p.m. Saturday
Member Price: $70 **Non-Member Price:** $95
Location: American Center for Physics

Ruth Howes, 714 Agua Fria St., Santa Fe, NM 87501; rhowes@bsu.edu

Participants will become familiar with the resources contained in this archive and library devoted to the history of physics. They will learn how to find materials from the collection online, how to use them, and what the rules are for classroom use. Emphasis will be placed on how to use the materials in teaching and for enriching instruction perhaps through science club activities. Participants will also learn about the History Programs' teacher guides on women and underrepresented minorities in physics.

W03: FPGAs

Sponsor: Committee on Apparatus
Time: 8 a.m.–12 p.m. Saturday
Member Price: $80 **Non-Member Price:** $105
Location: PHY - 3301

Kurt Wick, University of Minnesota, 116 Church St. SE, Minneapolis, MN 55455; wick@umn.edu

In this workshop you will work with FPGAs (Field Programmable Gate-Arrays.) Unlike the older, traditional application specific standard products (ASSPs), such as the 4000 or 7400 series chips, FPGAs contain 100k or more logic gates which can be operated reliably in the MHz to GHz range. These properties make FPGAs ideally suited to be used in an advanced lab course teaching digital logic or to have them directly incorporated into lab projects. You will interface the Digilent's FPGA hardware boards and learn how to implement combinational and sequential digital logic using a graphical approach and a hardware descriptive language, such as Verilog. You will build an interactive 4 bit adder. Pulse width modulation (PWM) technique will be applied to build a digital-to-analog converter to play music. Time permitting, additional exercises may be implemented such as using an IP core to create a sinusoidal frequency synthesizer or a successive-approximation analog-to-digital converter.

W04: Ramps Bungee Cords: Bringing It Together–Modeling, Assessment, and Engineering

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 3213

Aaron Osowiecki, Boston Latin School, 78 Ave. Louis Pasteur, Boston, MA 02115; aosowiecki@bostonpublicschools.org

The Next Generation Standards call for the integration of modeling, content, and engineering within science classrooms. In our energy unit, students "discover" energy conservation by analyzing speed data obtained from rolling marbles down a series of ramps of different heights and slopes. After some significant practice applying the concept, students apply energy conservation to design and build a rubber band bungee cord to provide a safe, yet thrilling drop, for a raw egg. Participants in this session will explore this unit, collecting their own data and building their own bungee cord while seeing how we incorporate formative and summative assessment, as well as "5E" design, throughout the unit to ensure student success.

W05: Data Analysis for Astronomy Educators

Sponsor: Committee on Space Science and Astronomy
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 1201

Kirk Borne, George Mason University, Planetary Hall, Room 115, 4400 University Dr., MS 3F3, Fairfax, VA 22030; kborne@gmu.edu

In the same way that content-based marketing is the primary way that businesses use to engage with customers, we need content-based activities to engage with students... i.e., we must not simply try to "sell" scientific ideas to students outside of the context of those ideas (how they were discovered, what they mean), but we should show them the story that led to the scientific discovery, how scientific inquiry is done, and why it is done. This workshop will explore data activities in the classroom as a means to learning science content.

W06: Integrating Physics and Geology into Engineering for STEM

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Saturday
Member Price: $70 **Non-Member Price:** $95
Location: PHY - 3115

Evelyn Restivo, 144 Creekview Circle, Maypearl, TX 76064; erestivo2001@yahoo.com

Janie Head, John Taber

Designing STEM-related activities to integrate Physics and Geology: STEM activities are designed and developed to relate subjects to career opportunities using engineering methods and technology. The focus on physics topics that integrate geological techniques allows an additional insight into careers that span across specific science areas and peer into the engineering and technological advances of the future that will be discovered and used by the students in our classrooms today. Design activities will include Energy of Wave Motion for Seismic Waves, Energy of Wave Motion in Different Materials, Energy in Cratering and Surface Composition, Techniques and Energy Associated with Core Sampling, Logging Processes of Drilling, and Energy Techniques Associated with Searching for Magnetic Field Patterns

W07: Learn Physics While Practicing Science: Introduction to ISLE

Sponsor: Committee on Physics in Undergraduate Education
Co-sponsor: Committee on Physics in Two-Year Colleges
Time: 8 a.m.–5 p.m. Saturday
Member Price: $85 **Non-Member Price:** $110
Location: PHY - 3220

Eugenia Etkina, Rutgers University, Graduate School of Education, 10 Seminary Place, New Brunswick, NJ 08901; eugenia.etkina@gse.rutgers.edu

David Brookes, Gorazd Planinšič

Participants* will learn how to modify introductory physics courses to help students acquire a good conceptual foundation, apply this knowledge effectively in problem solving, and develop the science process abilities needed for real life work using Investigative Science Learning Environment (ISLE). We provide tested curriculum materials including: The Physics Active Learning Guide and the Instructor Guide (ALG has 30 or more activities per textbook chapter for use with any textbook, including a new ISLE-based textbook); (b) a website with over 200 videotaped experiments and questions for use in the classroom, laboratories, and homework; and (c) a set of labs that can be used to construct, test and apply concepts to solve problems. During the workshop we will illustrate how to use the materials in college and high school physics courses to have an explicit emphasis on using the processes of science and various cognitive strategies consistent with the NGSS. We will specifically focus on 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.

W08: PIRA Lecture Demonstrations I

Sponsor: Committee on Apparatus
Time: 8 a.m.–5 p.m. Saturday
Member Price: $115 **Non-Member Price: $140**
Location: PHY - 1412

Dale Stille, University of Iowa, Van Allen Hall, Department of Physics and Astronomy, Iowa City, IA 52242; dale-stille@uiowa.edu

Sam Sampere

Individuals taking this workshop will be offered a unique one-time experience, as this year we will be using the set of flagship physics demonstrations from the University of Maryland. Even if you have taken this workshop in the past, you may wish to take it again just for this opportunity. The topics in this workshop cover the standard first semester of physics instruction from Mechanics to Thermal, and is presented by an experienced team of lecture demonstrators. The format allows for, and encourages dialogue between instructors and participants. It is recommended that both Lecture Demonstrations 1 and 2 be taken, as this will cover the complete year of demonstrations needed for a typical introductory course. The demonstrations used and exhibited will be based on, but not limited to, the PIRA top 200 list of demonstrations. See http://www.pira-online.org for more info on this list. Also see http://faraday.physics.uiowa.edu/pira_meeting_pictures.htm and click on the "2015 Additional PIRA Workshop" link for additional information about this workshop as well as some pictures and movies from past workshops.

W09: Activity-based Physics in the High School Classroom

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Physics in High Schools
Time: 8 a.m–5 p.m. Saturday
Member Price: $95 **Non-Member Price: $120**
Location: PHY - 3104

Steve Henning, Department of Physics and Astronomy, Dickinson College, PO Box 1773, Carlisle, PA 17013; physfsh@gmail.com

Priscilla Laws, Maxine Willis

This hands-on workshop is designed for teachers in advanced physics classes such as AP, International Baccalaureate, and honors physics. Teachers attending should be interested in enabling their students to master physics concepts in mechanics by engaging in inquiry-based active learning. Participants will work with classroom-tested curricular materials drawn from the Activity Based Physics Suite materials. These curricula make creative use of flexible computer tools available from Vernier and PASCO. These materials have been developed in accordance with the outcomes of physics education research. Affordable access to the Suite materials for secondary school use is now available and will be discussed.

W10: Teaching Programming and Problem Solving Using LEGO EV_3 Robotics

Sponsor: Committee on Apparatus
Co-sponsor: Committee on Science Education for the Public
Time: 8 a.m.–5 p.m. Saturday
Member Price: $85 **Non-Member Price: $110**
Location: PHY - 3120

Jeremy Benson, Northern Illinois University, NIU STEM Outreach, Lowden Hall 307, DeKalb, IL 60115; jjbenson@niu.edu

Kids love robots! And everyone loves playing with LEGOs, but did you know there's a lot we can learn from them too! This workshop will explore the potential for problem solving and critical thinking, as well as engineering and design concepts, all using everyone's favorite robotic building blocks. We'll also be exploring ideas of basic programming and logic, all using the brand new LEGO EV3 robots and software. If you've been curious about what all the excitement is about, here's your chance to find out!

W11: Teaching Graphical Solutions for Forces & Kinematics

Sponsor: Committee on Teacher Preparation
Co-sponsor: Committee on Physics in High Schools
Time: 8 a.m.–5 p.m. Saturday
Member Price: $80 **Non-Member Price: $105**
Location: PHY - 1204

Kelly O'Shea, 35 W 65th St., Apt 2B, New York, NY 10023; kellyoshea@gmail.com

Graphical methods for solving problems are elegant, connect to calculus, and support students who typically struggle with strict formulaic problem solving. In this workshop, we will practice methods for solving kinematics and dynamics problems graphically using velocity-vs-time graphs and force vector addition diagrams. These approaches emphasize conceptual understanding and allow students to use diagrams as sense-making tools while solving challenging quantitative problems. Students often enjoy thinking geometrically—and you've never seen as true a joy as when a student realizes she can use the Law of Sines outside of math class. We will also learn and practice student-centered discussion techniques through several modes of "whiteboarding" (http://kellyoshea.wordpress.com/whiteboarding/). Using table-sized whiteboards to facilitate small group work and large group discussions supports students as they voice and debate their ideas with their peers. We will try a variety of techniques that focus on normalizing mistakes in the classroom, thinking through other students' work, and giving multiple opportunities for quieter students to engage their peers during class.

W12: Open Source Electronics for Laboratory Physics

Sponsor: Committee on Laboratories
Time: 1–5 p.m. Saturday
Member Price: $140 **Non-Member Price: $165**
Location: PHY - 3316

Zengqiang Liu, 720 4th Ave. S WSB 308, Saint Cloud State University, Saint Cloud, MN 56301; zliu@stcloudstate.edu

Open-source electronic devices are transforming laboratory physics education in unprecedented ways. More and more physics instructors have found that open-source electronics, such as Arduino, can provide them with wonderful teaching and learning opportunities. They can develop new laboratory activities and demonstrations, as well as exploratory and advanced projects, often involving their students. The cost is usually low. Participants of this workshop will dive right into interfacing sensors with Arduino compatible platforms. They will acquire first-hand experience constructing circuits and interfacing with sonic rangers, photogates, temperature probes, force gauges, accelerometers, magnetometers, SD cards, displays, user interfaces, and other common sensors, devices, and useful software. The workshop also provides basic training on computer programming and soldering. Each participant will be provided sensors and a standalone data acquisition device for their workshop activities. They can take everything home, except for force gauges. Participants must bring a laptop.

W13: Research-based Reforms to Introductory Physics for the Life Sciences

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: PHY - 3310

Joe Redish, University of Maryland, Department of Physics, John S. Toll Physics Building, College Park, MD 20742; redish@umd.edu

Ben Geller, Ben Dreyfus, Chandra Turpen

As part of the National Experiment in Undergraduate Science education (NEXUS), the University of Maryland has designed a two-semester IPLS course in the Fundamentals of Physics for Biologists. Blending interdisciplinary learning spaces and epistemological commitments, this course uses research-based pedagogies and research-based instructional design elements to provide IPLS students with a reformed introductory physics experience. Come hear about our open source material: our wiki text; our recitations; our growing library of context-rich problems for homework, quizzes, and exams; our growing library of clicker questions; and our pedagogical tools for achieving student-centered learning in a large-enrollment learning environment.

W14: Physics Research Mentor Training

Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on Diversity in Physics
Time: 1–5 p.m. Saturday
Member Price: $75 **Non-Member Price:** $100
Location: PSC - 3150

Renee Michelle Goertzen, APS, One Physics Ellipse, College Park, MD 20740; goertzen@aps.org

Many faculty and graduate students are placed in mentorship roles, although they rarely receive formal training in how to be an effective mentor. The Physics Research Mentor Training Seminar provides training for physics faculty, postdocs, and graduate students who are in mentorship roles. Participants will work through a portion of a 10-week seminar that includes themes such as establishing expectations, maintaining effective communication, addressing diversity, and dealing with ethical issues. Participants will improve their own mentoring skills and will learn how to facilitate mentoring seminars using a facilitation guide. This guide was developed by physics researchers and researchers from the University of Wisconsin who have previously adapted several mentor training curricula. Within each topic, the guide provides learning objectives, suggested activities, and case studies for discussion. The workshop is intended to help physics researchers improve their mentoring skills and to improve the experiences of the next generation of physicists.

W15: Preparing Faculty to Mentor Physics Students for Careers: Using the Careers Toolbox

Sponsor: Committee on Physics in Undergraduate Education
Time: 1–5 p.m. Saturday
Price: Free (Sponsored by AIP)
Location: PSC - 2136

Sean Bentley, Society of Physics Students, One Physics Ellipse, College Park, MD 20740; sbentley@aip.org

This workshop will give faculty an introduction to the Careers Toolbox, a valuable professional development tool for physics undergraduates. Focus will be on knowledge transfer, training the faculty to effectively implement the toolbox in curricular/co-curricular settings. The toolbox, the corresponding website, materials for career's offices, and instructional materials will all be covered. Each participant will receive a copy of the toolbox and related materials.

W16: Integrating Direct-Measurement Videos into Physics Instruction

Sponsor: Committee on Educational Technologies
Time: 1–5 p.m. Saturday
Member Price: $65 **Non-Member Price:** $90
Location: PHY - 1201

Peter Bohacek, Henry Sibley High School, 1897 Delaware Ave., Mendota Heights, MN 55118; peter.bohacek@isd197.org

Matthew Vonk

Direct-measurement videos (DMVs) are carefully recorded videos that allow students to measure and analyze events using physics concepts and reasoning. New generation DMVs have user-selectable parameters and scalable, draggable measurement tools that allow for inquiry style exploration. Students learn to develop scientific questions and design experiments to explore relationships. We'll share our collection of videos and teaching methods for integrating DMVs in introductory physics.

W17: Labs that May Appear at Many Levels

Sponsor: Committee on Physics in High Schools
Time: 1–5 p.m. Saturday
Member Price: $70 **Non-Member Price:** $95
Location: PHY - 3214

Paul Dolan, Northeastern Illinois University, 5500 N. St. Louis Ave., Chicago, IL 60625; p-dolan@neiu.edu

Do your favorite lab at any level in the curriculum! This workshop will provide participants with hands-on experience working with equipment from several physics lab exercises that can be adapted to being done at many different levels of the curriculum, potentially from Middle School to the Advanced Lab, thus moving the "spiral curriculum" from the lecture into the lab. Participants will cycle through the various stations to optimize their "hands-on" time. Documentation will be provided for each experiment with sample data, equipment lists, and construction or purchase info. Possible topics include (but are not limited to): the pendulum (in its many various forms), the ballistic pendulum, granular materials, lenses & image formation, NanoTech, and examples of exponential growth & decay, such as population simulations & radiation/counting. The presentations will be active and interactive.

W18: Creating Interactive Web Simulations Using HTML5 and Javascript

Sponsor: Committee on Educational Technologies
Time: 1–5 p.m. Saturday
Member Price: $70 **Non-Member Price:** $95
Location: PHY - 3306

Andrew Duffy, Department of Physics, Boston University, 590 Commonwealth Ave., Boston, MA, 02215; aduffy@bu.edur

HTML5 and JavaScript have replaced Java and Flash as the leading technology for in-browser software, with the ability to deliver high-performance, graphics-intensive simulations over the web to both personal computers and mobile devices. Participants in this workshop will learn to use this technology to create educational physics simulations that students can run on almost any computer, tablet, or smartphone that can browse the web. The workshop will cover HTML basics, the JavaScript programming language, graphics using the HTML5 canvas element, and essential user-interface controls. Participants should have some prior programming experience (in any language) and must bring their own laptop computers with up-to-date versions of Firefox, Chrome, and a programmer's text editor such as Notepad++ or TextWrangler. Participants are also encouraged to bring ideas for simulations they would like to create.

Workshops – Sunday, July 26

All workshops are held at the John S. Toll Physics Building (PHY) or Physical Sciences Complex (PSC).

W19: Demo Kit in a Boxs

Sponsor: Committee on Apparatus
Co-sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $75 **Non-Member Price:** $100
Location: PHY - 3306

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

Adam Beehler

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 theme at this workshop will be electricity and magnetism. This workshop is valuable for all educators – pre-HS through college. Participants will leave with demos and a box!

W20: Making Interactive Video Vignettes and Interactive Web Lectures

Sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Sunday
Member Price: $65 **Non-Member Price:** $90
Location: PHY - 3104

Bob Teese, 1268 Carlson Hall, Rochester Institute of Technology, 54 Lomb Dr., Rochester, NY 14623; rbtsps@rit.edu

Priscilla W. Laws, Patrick J. Cooney, Kathleen Koenig, Maxine C. Willis

The LivePhoto Physics Project is creating online activities that combine narrative videos with interactive, hands-on elements for the user including video analysis or making predictions based on replaying a short video (http://www.compadre.org/ivv). They can contain branching questions, where the user's answer affects the sequence of elements that follow. They are delivered over the Internet and run in a normal browser on the user's device. The same software runs both short Interactive Video Vignettes and Interactive Web Lectures for flipped classrooms or online courses. You will learn how to make vignettes and interactive web lectures using a free Java application. We will demonstrate the impact of select online activities on student learning. You need access to a web server to host your activities. Visit http://ivv.rit.edu/workshop to see detailed requirements for the web server and video equipment you will need. (Supported by NSF grants DUE-1122828 and DUE-1123118.)

W21: Just-in-Time Teaching

Sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Sunday
Member Price: $20 **Non-Member Price:** $45
Location: PHY - 3120

Andy Gavrin, IUPUI, Department of Physics, LD154 402 N. Blackford St., Indianapolis, IN 46202; agavrin@iupui.edu

For more than 15 years, faculty members in physics, math, engineering and many other fields have used Just-in-Time Teaching, also known as "JiTT." By creating a short time scale feedback loop between homework and the classroom, JiTT improves students' engagement with the course, promotes active learning in the classroom, and helps students to stay caught up in the class. JiTT also provides faculty with greater insight to their students' thinking about the subject. This workshop will introduce JiTT methods, and show how they can be implemented in a variety of educational settings. Participants will learn to implement JiTT using their LMS or free technology, and will be introduced to an online library of assignments that they can use or adapt. By the end of the session, participants will have several JiTT assignments usable in their own classes. We will also discuss tips and tricks for a successful implementation.

W22: Explorations in Arduino Physics: Ideas and Experiments that Integrate this Low-cost 8-bit Microcontroller into Your Classroom!

Sponsor: Committee on Laboratories
Co-sponsor: Committee on Apparatus
Time: 8 a.m.–12 p.m. Sunday
Member Price: $120 **Non-Member Price:** $145
Location: PHY - 3115

Brian Huang, 6333 Dry Creek Pkwy., Niwot, CO 80503; brian.huang@sparkfun.com

Using the simplicity and power of the open-source community, we have created several tools and hands-on demonstrations of physics experiments. For many years, data collection devices from Pasco and Vernier have helped classrooms gain a better insight to physical phenomena. We feel like the Arduino environment can take this to the next level and help students model and build an understanding around data measurement, uncertainty, and calibration. I'd like to present a variety of projects around teaching circuits, capacitance, and other fun physics areas using Arduino.

W23: Authentic Experimentation in Labs Using Structured Quantitative Inquiry

Sponsor: Committee on Laboratories
Time: 8 a.m.–12 p.m. Sunday
Member Price: $70 **Non-Member Price:** $95
Location: PHY - 3213

Joss Ives and Natasha Holmes, 6224 Agricultural Rd., University of British Columbia; Vancouver, BC V6T 1Z1; joss@phas.ubc.ca and nholmes@phas.ubc.ca

Doug Bonn

The Structured Quantitative Inquiry Labs (SQILabs) are a new pedagogy for teaching data analysis, modelling, and experimentation skills and concepts in physics labs. In this workshop, participants will learn about the SQILab structure and work through sample experiments in groups. Participants will explore quantitative tools students can use to compare measurements with uncertainty (internally, rather than to 'true' values) and use those tools to promote iterative experimentation cycles, where students reflect on comparisons and iterate to improve measurements. Several examples of these cycles will be applied to specific experiments and participants will also reflect on their own teaching labs and adapt the SQILab structure to an experiment of their choice. Participants can expect to learn about a new pedagogical approach to physics labs and leave the workshop with tools, ideas, and structure to implement the approach in their own courses, whether or not labs are attached to lecture or lecture content.

W24: Creating Invention Tasks that Develop Flexible Mathematical Reasoning Skills in Physics

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: PHY - 3220

Suzanne White Brahmia, Department of Physics and Astronomy, Rutgers, The State University of New Jersey, 136 Frelinghuysen Rd., Piscataway, NJ 08854-8019; brahmia@rci.rutgers.edu

Andrew Boudreaux, Stephen Kanimn

Physics Invention Tasks, a set of supplemental curricular materials appropriate for high school and college, provide students with opportunities for the generative and flexible use of mathematics. Through sequences of tasks, students make sense of physical quantities and laws, work that prepares them for future instruction and learning. An important feature is students' invention of algebraic descriptions of systems and phenomena. Participants will learn about the theoretical underpinnings of invention instruction[1] and gain experience with tested and freely, web-available Physics Invention Tasks. Participants will also develop their own invention tasks and learn to modify large and small group activities to explicitly promote flexible and generative mathematical reasoning. Such reasoning is consistent with the NGSS science practices, but is often not well developed in traditional courses.

1. D. Schwartz and J. Bransford, "A Time for Telling," *Cog. Instr.* **16** (4), 475 (1998).

W25: Beyond the Atom

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $75 **Non-Member Price:** $100
Location: PHY - 3214

Karen Jo Matsler, 3743 Hollow Creek Rd., Arlington, TX 76001; kjmatsler@gmail.com

Jan Mader, Janie Head, Evelyn Restivo

Using materials developed by the Perimeter Institute, this session will show you how to engage students in learning about particle physics. Activities include helping students with concepts regarding Rutherford's scattering experiment, conservation of charge and momentum to analyze images from CERN, exploring a quark model while taming the particle zoo, and analyzing data from Fermilab's D-Zero accelerator. Recommended for educators involved with students in grades 8-16.

W26: Research-based Tools for Teaching Quantum Mechanics

Sponsor: Committee on Research in Physics Education
Co-sponsor: Committee on Physics in Undergraduate Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 1201

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

Emily Marshmann

We have been engaged in research to improve students' understanding of upper-level quantum mechanics. In this workshop, we will discuss the common difficulties students have in learning quantum mechanics and how the use of research-based learning tools can reduce these difficulties. These learning tools include Quantum interactive learning tutorials (QuILTs), concept-tests for peer instruction, and reflective problems which are conceptual in nature. QuILTs are based upon research in physics education and employ active-learning strategies and Open Source Physics visualization tools. They attempt to bridge the gap between the abstract quantitative formalism of quantum mechanics and the qualitative understanding necessary to explain and predict diverse physical phenomena. This workshop is targeted to instructors who would like to supplement their existing course material with research-based field tested tools. Participants will work in small groups on research-based interactive tools that incorporate paper-pencil tasks and computer simulations. We will discuss the general pedagogical issues in the design of the learning tools and how they can be adapted to individualized curricula. Some learning tools deal with contemporary topics such as quantum teleportation that can be taught using simple two level systems. Participants are encouraged to bring their own laptops. This work is supported by the National Science Foundation.

W27: Computational Physics

Sponsor: Committee on Physics in Two-Year Colleges
Time: 8 a.m.–12 p.m. Sunday
Member Price: $70 **Non-Member Price:** $95
Location: PHY - 3316

Greg Mulder, Linn-Benton Community College, 6500 Pacific Blvd. SW, Albany, OR 97321; mulderg@linnbenton.edu

In this workshop I will focus on using VPython in a first-year Physics with Calculus sequence. There are three main ways that physicists solve problems: analytically, empirically and computationally. The exercises that I will present represent 20 minute per week classroom activities that have allowed us to introduce computational problem solving into the first-year physics classroom experience. No prior programming or VPython experience is required. Please bring your own laptop preferably with VPython already downloaded by going to http://vpython.orgn.

W28: Interactive Engagement in the Upper-division: Methods and Materials from CU-Boulder

Sponsor: Committee on Physics in Undergraduate Education
Co-sponsor: Committee on Research in Physics Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $72 **Non-Member Price:** $97
Location: PHY - 1204

Steven Pollock, 390 UCB, Department of Physics, University of Colorado, Boulder, CO 8030; Steven.Pollock@colorado.edu

Marcos (Danny) Caballero, Charles Baily, Bethany Wilcox

The physics department at the University of Colorado Boulder has been developing active-learning materials and research-based assessments for courses beyond the introductory level: Modern Physics, Math Methods/Classical Mechanics, Quantum Mechanics, Electrostatics & Electrodynamics. We have shown that improved student learning can be achieved in advanced courses by adopting and adapting student-centered pedagogies and instructional techniques proven effective in introductory courses. This workshop will provide participants with an overview of the research base and course transformation process, along with a guided exploration of our online resources. Discussions of how learning goals for advanced courses differ from those for introductory courses will help you to adapt these resources to your classroom. We will provide practical demonstrations of how clicker questions and activities can be incorporated into advanced courses. Please bring a laptop. (You will also receive a flash drive containing a complete collection of our latest materials and assessments. See http://www.colorado.edu/sei/physics.)

W29: Activities for Learning About Climate and Climate Change

Sponsor: Committee on Science Education for the Public
Co-sponsor: Committee on Physics in Pre-High School Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 0405

Brian Jones, Colorado State University, Fort Collins, CO 80523; bjones@lamar.colostate.eduson

During the day, the Earth is warmed by sunlight that shines on it. This is something that your students can see, something that they can feel. But, over the course of a day, the surface of the Earth receives more radiant energy from clouds and the lower atmosphere than it does from the Sun. The influence of this thermal radiation is critically important for an understanding of the Earth's climate and how it is changing. In this workshop we'll share activities that make this invisible form of energy transfer tangible. We'll also share activities that illuminate other important but complex concepts, such as how climate models work, how feedbacks—both positive and negative—affect the climate. Our goal is to give you a set of tools to give your students a real understanding of the Earth's climate and how scientists predict its development in the future.

W30: NEXUS Physics Labs for Biology Students

Sponsor: Committee on Laboratories
Co-sponsor: Committee on Apparatus
Time: 8 a.m.–5 p.m. Sunday
Member Price: $87 **Non-Member Price:** $112
Location: PHY - 3310

Kim Moore, University of Maryland, Department of Physics, John S. Toll Physics Building, College Park, MD 20742; moorephysics@gmail.com

Wolfgang Losert, Nawal Benmouna, James Vesenka, Simon Capstick

A recent focus in the Physics Education community has been reinventing/revising the Introductory Physics for Life Sciences curriculum in order to better serve the evolving needs of these students (e.g., the May 2014 IPLS Conference and the June 2014 Gordon Research Conference). In response to these concerns, the University of Maryland Physics Education Research Group has developed (2012-2013) and tested (2012-2015) a year-long, open-ended, interdisciplinary laboratory curriculum (read more about this in the most recent special issue of AJP: K. Moore, J. Giannini & W. Losert "Toward better physics labs for future biologists," *Am. J. Phys.* **82** (5), May 2014, http://dx.doi.org/10.1119/1.4870388). This day-long workshop will provide an introduction to this lab curriculum, including the educational design, the pedagogical and epistemological philosophies, and the high-tech equipment used. Additionally, a variety of "first-users" from institutions adopting this curriculum (incl. Two-Year Colleges) will discuss the challenges and successes for adapting this curriculum to work in their local educational setting. If you are interested in seeing some high-tech., data rich investigations at the intersection of physics and biology, please join us!

W31: Creating JavaScript Simulations and Electronic Books for Computers and Tablets

Sponsor: Committee on Educational Technologies
Time: 8 a.m.–5 p.m. Sunday
Member Price: $80 **Non-Member Price:** $105
Location: PHY - 3312

Mario Belloni, Physics Department, Davidson College, Davidson NC 28036; mabelloni@davidson.edu

Francisco Esquembre, Larry Engelhardt

In this full-day workshop we will describe the pedagogy and technology necessary to use, modify, and create HTML5 and JavaScript-based simulations that run on both computers and tablets. Our approach uses the Easy Java Simulations (now renamed Easy Java/JavaScript Simulations, EjsS) Modeling Tool to create, explore and deliver JavaScript simulations. In the morning you will learn how to use the EjsS program to download one of the 100 existing simulations from the ComPADRE digital library, and inspect and modify it using EjsS. You will also learn how to export the modified simulation for distribution and run it on an independent computer and on a tablet using the EjsS Reader App (Android or iOS). In the afternoon you will learn how to create an electronic book from several existing simulations and will have time to work on a project of your choice to practice your learning in a hands-on project.

W32: Preparing to Teach Physics to the Next Generation

Sponsor: Committee on Physics in High Schools
Co-sponsor: Committee on Teacher Preparation
Time: 8 a.m.–5 p.m. Sunday
Member Price: $80 **Non-Member Price:** $105
Location: PHY - 3203

Bradford Hill, 9625 SW 125th Ave., Beaverton, OR 97008; bradfordhill@gmail.com

Heather Moore, Scott Murphy, Jordan Pasqualin

This hands-on workshop is driven by the recurring question: "How do we find and use patterns in nature to predict the future and understand the past?" By utilizing the ideas described in NGSS, Patterns guide participants to make predictions, plan and conduct experiments, collect data, analyze the results, argue from evidence, and evaluate their conclusions. Participants engage in the practices of science throughout the workshop, starting with anchoring experiments that contextualize four common patterns in physics: linear, quadratic, inverse and inverse square. Inquiry and engineering experiences serve to spiral the anchoring patterns with new physics concepts, developing conceptual, graphical, and symbolic understanding. An integral component of the course is continued use of evidence-based reasoning and data-informed decision-making. Each experiment begins with an initial guess that is contrasted with a data-informed prediction, found by extrapolation of the pattern in the data. This allows students to explicitly compare low-to-high evidence predictions and builds a strong case for why we engage in scientific practices. Creating models and explicitly discussing their limitations is also key. The Patterns Approach has been used within freshman and IB courses and is published in the NGSS issue of *The Science Teacher,* March 2013.

W33: PIRA Lecture Demonstrations II

Sponsor: Committee on Apparatus
Time: 8 a.m.–5 p.m. Sunday
Member Price: $115 **Non-Member Price:** $140
Location: PHY - 1410

Dale Stille, Rm 58 Van Allen Hall, Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242; dale-stille@uiowa.edu

Sam Sampere

Individuals taking this workshop will be offered a unique one-time experience, as this year, we will be using the set of flagship physics demonstrations from the University of Maryland. Even if you have taken this workshop in the past you may wish to take it again just for this opportunity. The topics in this workshop cover the standard first semester of physics instruction from E&M to Modern plus Astronomy, and is presented by an experienced team of lecture demonstrators. The format allows for, and encourages dialogue between instructors and participants. It is recommended that both Lecture Demonstrations 1 and 2 be taken, as this will cover the complete year of demonstrations needed for a typical introductory course. The demonstrations used and exhibited will be based on, but not limited to, the PIRA top 200 list of demonstrations. See http://www.pira-online.org for more info on this list. Also see http://faraday.physics.uiowa.edu/pira_meeting_pictures.htm and click on the "2015 Additional PIRA Workshop" link for additional information about this workshop as well as some pictures and movies from past workshops.

W34: Modeling Instruction for University Physics

Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 1201

Eric Brewe, 11200 SW 8th St., Miami, FL 33199; eric.brewe@gmail.com

This workshop will provide participants an opportunity to engage with the Modeling Instruction for University Physics materials. These materials have been used to consistently improve students conceptual understanding and attitudes toward learning science. Features of the Modeling Instruction curriculum and pedagogy include integrated lab and "lecture" class components, focus on use of and interpretation of multiple representations, and the role of conceptual models for understanding physics. Participants will gain access to all materials developed to support Modeling Instruction.

W35: Metacognition and Reasoning in Physics

Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 3220

Mackenzie Stetzer, Department of Physics, 5709 Bennett Hall, Room 120, Orono, ME 04469-5709; mackenzie.stetzer@maine.edu

Andrew Boudreaux, Sara Julin, Mila Kryjevskaia

Experts tend to consciously monitor and evaluate their own progress when confronted with a new challenge, while novices often persist in using unproductive approaches. We have been investigating the relationships among student metacognition, conceptual understanding, and qualitative reasoning in introductory and upper-division physics courses. The two primary goals of this project are to develop classroom activities that explicitly promote student metacognition in the context of specific physics content and to design and test methodologies capable of assessing student metacognition in physics. During this workshop, we will describe the research base on student metacognition in physics, and participants will gain firsthand experience working through selected activities. In addition, methods for assessing students' metacognitive abilities will be discussed.

W36: Physics Union Mathematics

Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $65 **Non-Member Price:** $90
Location: PHY - 3120

Eugenia Etkina, Rutgers University, Graduate School of Education, 10 Seminary Place, New Brunswick, NJ 08901; eugenia.etkina@gse.rutgers.edu

Suzanne Brahmia, Robert Zisk

Physics Union Mathematics (PUM) is a set of supplemental curricular materials spanning middle school through high school designed to develop the Science and Engineering Practices outlined in the NGSS. The philosophical foundation of PUM is Investigative Science Learning Environment (ISLE). An important emphasis of PUM is the implicit development of mathematical thinking and the explicit and appropriate use of grade-level mathematics in the context of science practices. Using the PUM curricular materials, participants will learn how to modify physical science and physics courses to incorporate Science Practices and the Crosscutting Concepts outlined in the NGSS. We provide tested curriculum materials including: Sample materials from the PUM website (curriculum/solutions/ assessments freely available after the completion of workshop) (b) a website with over 100 short invention activities designed to develop mathematical reasoning; and (c) a website with over 200 videotaped experiments and questions for use in classwork/laboratories/homework. The workshop is intended for middle and high school physics teachers and teacher educators. Please bring a laptop with Quicktime if you have one. We recommend taking ISLE workshop prior to taking PUM workshop.

W37: Fun, Engaging and Effective Labs and Demos with Clickers, Video Analysis and Computer-Based Tools

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $75 **Non-Member Price:** $100
Location: PHY - 3104

David Sokoloff, Department of Physics, University of Oregon, Eugene, OR 97403-1274; sokoloff@uoregon.edu

Priscilla Laws, Ronald Thornton

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 new activities in RTP and ILD using clickers, video analysis and computer-based tools. The topics will be mechanics 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. These materials are also available for high schools in the Activity Based Physics High School e-dition. The following will be distributed: Modules from the Third Edition of RTP, the ILD book, the Physics with Video Analysis book and CD, and *Teaching Physics with the Physics Suite* by E.F. Redish.

W38: Physics of Toys I: Force, Motion, Light, and Sound

Sponsor: Committee on Science Education for the Public
Co-sponsor: Committee on Physics in Pre-High School Education
Time: 1–5 p.m. Sunday
Member Price: $70 **Non-Member Price:** $95
Location: PHY - 3306

Beverley Taylor, Miami University, Hamilton, 1601 University Blvd., Hamilton, OH 45011; taylorba@miamioh.edu

Stephen Luzader

This hands-on workshop is designed for teachers at all levels in search of fun physics demonstrations, lab experiments, and interactive materials through the use of ordinary children's toys. More than 50 toys will be demonstrated, and the physical principles related to these toys will be discussed. This workshop will concentrate on toys that illustrate the concepts of force, equilibrium, linear and rotational motion, optics and light, sound, and waves. You will have the opportunity to participate in both qualitative and quantitative investigations using some of these toys. The workshop leaders 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 also be used for informal presentations to public groups of all ages, whether children or adults.

W39: Facilitating Student Self-reflection & Personalized Instructor Feedback

Sponsor: Committee on Teacher Preparation
Time: 1–5 p.m. Sunday
Member Price: $65 **Non-Member Price:** $90
Location: PSC - 2136

Dimitri R. Dounas-Frazer, Department of Physics, University of Colorado, Boulder, CO 80309-0390; dimitri.dounasfrazer@colorado.edu

Daniel Reinholz, Danielle Champney, Gina Quan

As instructors, giving feedback to students is one of the most important parts of our jobs. This workshop highlights best practices for giving personalized feedback to students, tailored to the physics context. Additional topics include supporting students in peer-feedback activities and engaging them in self-reflection on peer and instructor feedback. The research-based tools and strategies presented here focus on students' development of a wide range of skills, from problem-solving and communication skills to "soft skills" such as perseverance on a challenging task and self-compassion in the face of failure. The target audience for this workshop includes secondary and post-secondary physics instructors, but the tools we present are broadly applicable beyond physics. The tools and strategies presented in this workshop have been developed by members of the Prism Network, a collaborative group of teachers and researchers committed to the use of reflection to promote holistic learning for students. This work has been supported by the AAPT Physics Education Research Leadership and Organizing Council (PERLOC) and the Cal Poly Center for Excellence in STEM Education (CESAME).

W40: Strategies to Help Women Succeed in Physics-related Professions

Sponsor: Committee on Women in Physics
Co-sponsor: Committee on Graduate Education in Physics
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: PHY - 1304

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

Women are severely under-represented in physics-related professions. This workshop will explore strategies to help women faculty members in K-12 education, colleges, and universities understand and overcome barriers to their advancement in careers related to physics. A major focus of the workshop will be on strategies for navigating effectively in different situations in order to succeed despite the gender schema, stereotypes, and subtle biases against women physicists. We will also examine case studies and learn effective strategies by role playing.

W41: Periscope: Looking into Learning in Best-practices University Physics Classrooms

Sponsor: Committee on Teacher Preparation
Co-sponsor: Committee on Physics in Undergraduate Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: PSC - 3150

Renee Michelle Goertzen, One Physics Ellipse, College Park, MD 20740; goertzen@aps.org

Rachel E. Scherr

Periscope, a new resource under development, provides physics faculty, graduate teaching assistants, undergraduate learning assistants, and preservice physics teachers with the opportunity to "look into learning" in best-practices university physics classrooms. Periscope is organized into short lessons that highlight significant topics in the teaching and learning of physics, such as formative assessment or cooperative learning. Topics are introduced through captioned video episodes of introductory physics students in the classroom, chosen to prompt collaborative discussion. This workshop will introduce participants to the resource and teach them how to adapt the materials for settings ranging from weekly meetings to all-day sessions.

W42: Intermediate and Advanced Laboratories

Sponsor: Committee on Laboratories
Time: 1–5 p.m. Sunday
Member Price: $85 **Non-Member Price:** $110
Location: PHY - 3214

Jeremiah Wililams, 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.

W43: Next Generation Physics and Everyday Thinking

Sponsor: Committee on Physics in Pre-High School Education
Co-sponsor: Committee on Teacher Preparation
Time: 1–5 p.m. Sunday
Member Price: $64 **Non-Member Price:** $90
Location: PHY - 1204

Fred Goldberg, San Diego State University, 6475 Alvarado Rd., Suite 206, San Diego, CA 92120; fg052144@gmail.com

Stephen Robinson, Edward Price

The project team who developed PET, PSET and LPS have made extensive revisions to those curricula, combining them into a new set of modules that offer flexibility in implementation and which are better aligned with the NGSS and other similarly aligned State Standards. This workshop will focus in on how students learn with the new materials, and will be organized for both faculty who already teach one of the previous curricula, as well as faculty who are considering the curriculum for the first time. Next Gen PET consists of six modules: (1) developing models for magnetism and static electricity; (2) energy; (3) forces; (4) waves; (5) matter and interactions; and (6) teaching and learning physical science. There is a major focus on scientific and engineering practices throughout the modules. The new design provides flexibility for different formats and content sequences to serve the needs of instructors and students in small-enrollment physics or physical science courses for prospective elementary or middle school teachers, large-enrollment general education courses offered in lecture-style settings, science methods courses, or workshops for in-service teachers. An extensive set of online tutorial-style homework assignments and video demonstrations accompany the in-class activities.

Session & Workshop Sponsors List

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Teacher Preparation: W11, W32, W39, W41, W43, BD, CB, DH, EE

Two-Year Colleges: W07, W27, CE, ED, FL, GA

Undergraduate Education: W07, W13, W15, W26, W28, W41, AH, AJ, AK, BA, BF, BK, DC, DG, EB, GG, GI

Women in Physics: W14, W40, BL, DB, EG, FD

2015 Shared Book Exhibit

(in Exhibit Hall: SSU-Grand Ballroom)

CRC Press/Taylor & Francis Group

1. John Matolyak, *Essential Physics*
2. Russell L. Herman, *A Course in Mathematical Methods for Physicists*
3. Jesus Rogel-Salazar, *Essential MATLAB and Octave*
4. Peter J. O'Donnell, *Essential Dynamics and Relativity*
5. Richard Fitzpatrick, *Oscillations and Waves: An Introduction*
6. Anthony C. Fischer-Cripps, *Fischer-Cripps Student Companion Set* (5 Volumes)
7. Alastair I.M. Rae, *Quantum Mechanics*, Fifth Edition
8. Joseph C. Amato, *Physics from Planet Earth – An Introduction to Mechanics*
9. Roland Kjellander, *Thermodynamics Kept Simple-A Molecular Approach: What is the Driving Force in the World of Molecules?*
10. John Kimball, *Physics Curiosities, Oddities, and Novelties*
11. Nicholas Tsoulfanidis, *Measurement and Detection of Radiation,* Fourth Edition
12. Robert Ehrlich, *Renewable Energy: A First Course*
13. Andrew Rex, *Commonly Asked Questions in Physics*
14. Titus A. Beau, *Introduction to Numerical Programming: A Practical Guide for Scientists & Engineers*
15. Iulian Ionita, *Condensed Matter Optical Spectroscopy: An Illustrated Introduction*

Ergopedia, Inc.

1. Tom Hsu, PhD, Manos Chaniotakis, PhD, Michael Pahre, PhD, *Essential Physics*, Second Edition

Jim Kadel

1. Jim Kadel, *Before You Enter*

Session SPS: SPS Undergraduate and Graduate Outreach Poster Session

Location: SSU – Grand Ballroom
Sponsor: AAPT, SPS
Date: Sunday, July 26
Time: 8–10 p.m.

Presider: Sean Bentley

SPS02: 8–10 p.m. Acoustic Impedance Measurements on Woodwind Instruments

Poster – Herbert Jaeger, Miami University, Department of Physics, Oxford, OH 45056; jaegerh@MiamiOH.edu

Robert Durrough, Miami University

The acoustic impedance is a key quantity for the characterization of acoustic properties of an air column. We have built a simple impedance transducer and used it to measure the acoustic impedance of a clarinet and a tenor saxophone. Moreover, we studied the effect of tone holes on the acoustics of an air column. This poster will detail the workings of the transducer and present results of impedance measurements on these woodwind instruments.

SPS03: 8–10 p.m. A Taxonomy of Conceptions About Density

Poster – Ashley Elaine Miller, Grove City College, 200 Campus Dr., Grove City, PA 16127; lindowae1@gcc.edu

DJ Wagner; Grove City College

Conceptions concerning density have been the subject of many studies, dating at least as far back as Piaget. These studies have probed many aspects of density understanding in various domains. In this poster, we present a taxonomy of conceptions about density. The conceptions described in this taxonomy have been identified by prior studies and/or our own interviews and assessment results.

SPS04: 8–10 p.m. PRISM: Developing a Student-Led Peer-Mentoring Program for Undergraduate Physics Majors

Poster – Manher Jariwala, Boston University, Department of Physics, 590 Commonwealth Ave., Boston, MA 02215; manher@bu.edu

Emily Ghosh, Molly Herman, Boston University

We describe a new, student-led peer-mentoring program at Boston University for undergraduate physics majors called PRISM (PeeRs for Incoming Physics Majors). We discuss the process of working with undergraduates in initiating the effort and developing the goals of the program. We also detail the resulting structure of the program, featuring one-to-one meetings between upper-class mentors and first-year mentees, and the measurement of mentee attitudes regarding comfort, confidence, and identity as a physics major, at different points in their first year on campus. Throughout, we focus on the ownership role of students in this program and its impact on the undergraduate physics learning community within our department

SPS05: 8–10 p.m. Physics, Nuclear Energy and the Informed Voter: Connecting the Dots

Poster – Sarah H. Stroh, American University, 4400 Massachusetts Ave., Washington, DC 20016-8058; ss0215a@american.edu*

Nuclear issues, while sometimes hotly contested, are not often contemplated or even considered by the average voter. Yet voter choices pertaining to nuclear energy decisions hold weight, often because they affect the surrounding environment and economy. One aim of the present study is to address the question: "What role does physics play in voter choices pertaining to nuclear energy issues?" To address this question, an electronic survey of American University students in the spring of 2015 investigated students' conceptions of nuclear energy issues using a 3-tiered approach. The first tier targeted individual levels of understanding as they pertained to formal physical knowledge on issues involving nuclear energy. The second tier

Sunday, July 26 Highlights

AAPT Workshops

Registration:
7 a.m.–4 p.m. — Stamp Student Union Foyer

Publications Committee:
8–10 a.m. — Marriott - 0101

Meetings Committee:
8–10 a.m. — Marriott - 0105

Resource Letters Committee:
10:30–1:30 p.m. — Marriott - 0102

Section Officers / Representatives:
5:30–8 p.m. — SSU - Charles Carroll B

Sunday Evening Registration:
5:30–9 p.m. — Stamp Student Union Foyer

Committee Meetings, 6:30–7:45 p.m.
– ALPhA Committee — Juan Ramon Jimenez
– Interests of Senior Physicists — B. Banneker B
– Physics in Undergrad. Educ. — Charles Carroll A
– Teacher Preparation — Margaret Brent A
– Women in Physics — Margaret Brent B

High School Share-A-Thon:
6–8 p.m. — SSU - Benjamin Banneker A

Physics Fair Play:
6:30–8 p.m. — SSU - Hoff Theater

Exhibit Hall Opens / Welcome Reception:
8–10 p.m. — SSU - Grand Ballroom

SPS Undergraduate Research and Outreach Poster Session and Reception
8–10 p.m. — SSU - Grand Ballroom

elicited individual conceptions regarding nuclear energy issues and how they translated into voter choices. The third focused on potential linkages between the respondents' present knowledge and their voting patterns. A statistical analysis of the survey results will be presented.

*Sponsored by: Dr. Teresa L. Larkin, American University

SPS07: 8–10 p.m. Mapping Cold Absorption Clouds in the Milky Way

Poster – Erica Ling, Penn State Abington, 1600 Woodland Rd., Abington, PA 19001; ams@psu.edu*

Anju John, Tamara Bernardo, Patrick O'Neill, Ann and Carl Schmiedekamp, Penn State Abington

The 20-meter radio telescope at the National Radio Astronomy Observatory, Greenbank, WV, was used to detect the extent of cold absorption features in the 21-cm neutral hydrogen emission near the Milky Way's equator. Multiple velocities were detected in the absorption features. Our results is compared to previously measured data.

*Faculty mentors for this project were Ann Schmiedekamp and Carl Schmiedekamp

SPS08: 8–10 p.m. An Optimization Algorithm of Lunar Spacecraft Orbit

Poster – Guodong Weng, School of Physics & Engineering,Sun Yat-sen University, Guangzhou, 510275 China; wegodem@qq.com

The fuel is very heavy for a spacecraft, so it is important to find a way to minimize the fuel consumption. In this paper, we try to study Chang'e 3 Rover's orbit design launched by China in 2013 to find an optimum strategy. Chang'e 3 Rover start orbit modification at the perilune of elliptical orbit. After landing orbit, main reduction and rapid adjustment of three stages, the distance from spacecraft to lunar surface would be from 15 km to 2.4 km which is located at 19.51°W, 44.12°N. By using Genetic Algorithm to calculate the spacecraft's orbit and the perilune of elliptical orbit. Then, we calculate the difference of squares for lunar surface's height, and get the precise location for spacecraft landing and we also find out the best orbit to minimize fuel consumption.

SPS10: 8–10 p.m. Reactor Neutrino Flux Uncertainty Suppression on Daya Bay Experiment

Poster – Weiyi Wang, School of Physics & Engineering, Sun Yat-sen University, Guangzhou, Guangdong 510275 China; wangwy0120@foxmail.com

Wei Wang, Sun Yat-sen University

The Daya Bay Reactor Neutrino Experiment has measured a non-zero value for the neutrino mixing angle theta 13 with a significance of 5.2 standard deviations. A rate-only analysis finds the neutrino oscillation parameter , $\sin^2$(2 theta 13) , in a three-neutrino framework.To maximize the sensitivity to theta 13, multi-detector experimental setups are applied for the reduction of the correlated errors and uncorrelated errors. Using the chi-square minimization, covariance matrix method, error propagating method, the suppression fraction is 0.05 for Daya Bay Experiment.

SPS11: 8–10 p.m. A Lagrangian for a Raindrop Accretion Model

Poster – Jerome Quenum, Montgomery College, 2700 Snowbird Terrace, Apt. 9, Silver Spring, MD 20906; jerome.quenum@gmail.com

Bibi Abdullah, University of Maryland, College Park

Eugene Li, Montgomery College

Application of an energy approach to the raindrop accretion problem yields an Euler-Lagrange formulation. The Lagrangian, with a factorable structure, has been determined; the associated symmetries and models of air resistance have been incorporated.

SPS12: 8–10 p.m. A Study of Backing Splash of Falling Water

Poster – Tianyuan Liu, Southeast University, No. 2 Dongnandaxue Rd., Nanjing, P.R. China; 213143258@seu.edu.cn

This paper focuses on a phenomenon of energy concentration. After a volume of water falls freely into the deep water below, some splashes are caused and gain enough energy to reach the position that is higher than the free-fall height. Through experiment and theoretical analysis, the energy of each step during the process is calculated. Fluid mechanics and wave theory are also used to explain the formation mechanism.

SPS13: 8–10 p.m. Experimental Study on Falling Water Block's Explosion

Poster – Diwei Li, Southeast University, No. 2 Dongnandaxue Rd. Jiangsu 211189 China; ldwldc@126.com

It is rarely known by people that a water block of a certain size would explode after falling in the air for some time. In our experiment, the presence of this phenomenon was verified and later we changed different variable quantities, such as its volume, temperature, and the kind of the liquid, to learn more about its process. Finally, we drew quantitative conclusions. Meanwhile, its principle was explained successfully by our intensive analysis, which has something to do with air resistance and liquid surface tension, as well as turbulent flow. It is believed that our study can inspire today's agricultural irrigation system.

SPS14: 8–10 p.m. Mimicking the Heliosphere in the Sink

Poster – Yijie Xiao, Southeast University, No. 2 Dongnandaxue Rd., Nanjing, Jiangsu 211189 China; yuetaohannosy@163.com

Muyang Tian, Southeast University

Recently, it was announced by NASA that the 'Voyager 1' satellite had reached the edge of the solar system, which is called "heliosphere". It is the first satellite that human beings have used to explore the outer space. Since we know little about the heliosphere, which is the furthest place where the solar wind can reach, we designed an experiment to simulate the solar wind and the heliosphere at home by pouring a stream of water into a sink. The experiment is aimed to investigate the relationship between the velocity and the edge of stream, which could be analogized to the behavior of solar wind. Qualitative and semi-quantitative results have been obtained, which might be a useful reference for further research.

SPS15: 8–10 p.m. On Helmholtz Carousel

Poster – Yifan Li, No. 2 Dongnandaxue Rd., P.R. China Nanjing, Jiangsu 211189 China; 15850656599@163.com

The paper is mainly to explore the relationship between Helmholtz carousel rotation speed and bottle shape. We built up the carousels using empty mineral water bottles, and tested the device by changing the frequency of the voice and the shape of the bottleneck. Experiments show that the shape of the bottleneck does have strong influence on the system. Because of the collimator effect, the direction of the air in and out of the bottle is not parallel, the momentum is different as well, resulting in the rotation of the device.

SPS16: 8–10 p.m. On the Wheel Splashing Phenomenon

Poster – Chengqi Lyu, Southeast University, No. 2 Dongnandaxue Rd., Jiangning Development Zone Nanjing, Jiangsu 211189 China lyuchq@gmail.com

Water will be splashed when the high-speed-rotating wheels touch the surface of it. Experimental data indicate that the angle of liquid increases first then decreases with the rotating speed increasing. The model which only considers surface tension fails to explain the phenomenon. As we take the extra force caused by the flow velocity difference into consideration, it matches the result of the experiment accurately.

SPS17: 8–10 p.m. Cosmic Ray Induced Bit-Flipping Experiment: A Project Update*

Poster – Matthew S. Parsons, Undergraduate Physics, Drexel University, 536 Alexander Rd., Princeton, NJ 08540; msp73@drexel.edu

Ed Callaghan, Daniel Douglas, Ge Pu, Drexel University

CRIBFLEX is a novel approach to mid-altitude observational particle physics intended to correlate the phenomena of semiconductor bit-flipping with cosmic ray activity. Here a weather balloon carries a Geiger counter and DRAM memory to various altitudes; the data collected will contribute to the development of memory device protection. We present current progress toward initial flight and data acquisition.

*This work is supported by the Society of Physics Students with funding from a Chapter Research Award.

SPS18: 8–10 p.m. The Bounce of Ping-Pong Ball Filled with Liquid

Poster – Heng Fang, Southeast University, No. 2 Dongnandaxue Rd., Nanjing, Jiangsu 211189; China fh_seu@163.com

We measure the bouncing altitudes of a Ping-Pong ball filled with certain amounts of water. In the experiment, the energy which transforms into the vibration energy of the liquid can be generally observed through the highest altitude. The ratio between vibration energy and total energy can be fit well using our theoretical model.

SPS19: 8–10 p.m. Observing Nebulosities: The Cygnus Superbubble

Poster - Christopher Christopherson, University of Wisconsin Oshkosh, 823 Kellogg St., Green Bay, WI 54303; chrisc32@uwosh.edu*

Nadia Kaltcheva, Steven Lund, Nick Grosskopf, Erik Robinson, University of Wisconsin Oshkosh

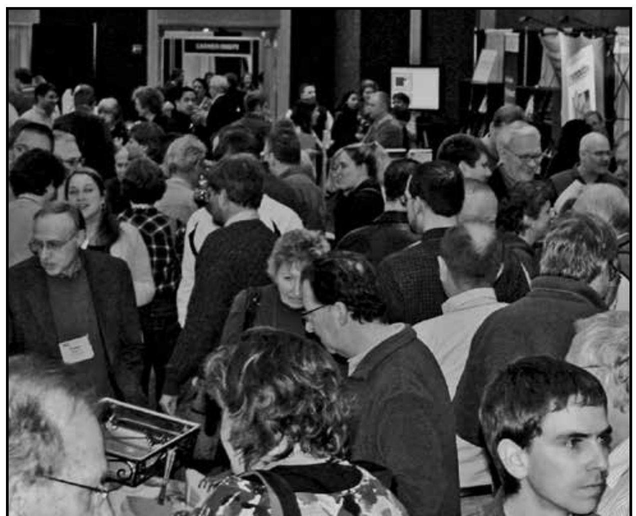
Observing Nebulosities, a student-led project at the University of Wisconsin Oshkosh, studies star-forming complexes in order to gain more understanding of their large-scale structure. Current observations reveal the Cygnus superbubble, the project's first target, to be a giant ring of hot gas more than 1000 light years in diameter filled with regions of star formation. It is surrounded by a shell of cooler hydrogen gas and a complex network of gaseous filaments and dust structures. We are imaging a large 22 x 17 degree field in the Hydrogen-alpha, Hydrogen-beta and Oxygen-III emission lines. Our project complements existing archive data and provides additional details on the interaction between the massive stars and the surrounding interstellar medium. Comparisons between the emission line observations allow us to trace regions where physical conditions change rapidly as well as the distribution of interstellar dust. The valuable hands-on experience yields insights on the entire research process.

*Sponsored by Mark Lattery, University of Wisconsin Oshkosh

Tours of Physical Sciences Complex (PSC) will be held:

Sunday, July 26: 5–6 p.m.
Monday, July 27: 12:30–1:30 p.m.
Tuesday, July 28: 12:30–1:30 p.m.
Wednesday, July 29: 12–1 p.m.

Meet in the lobby of PSC to take tour



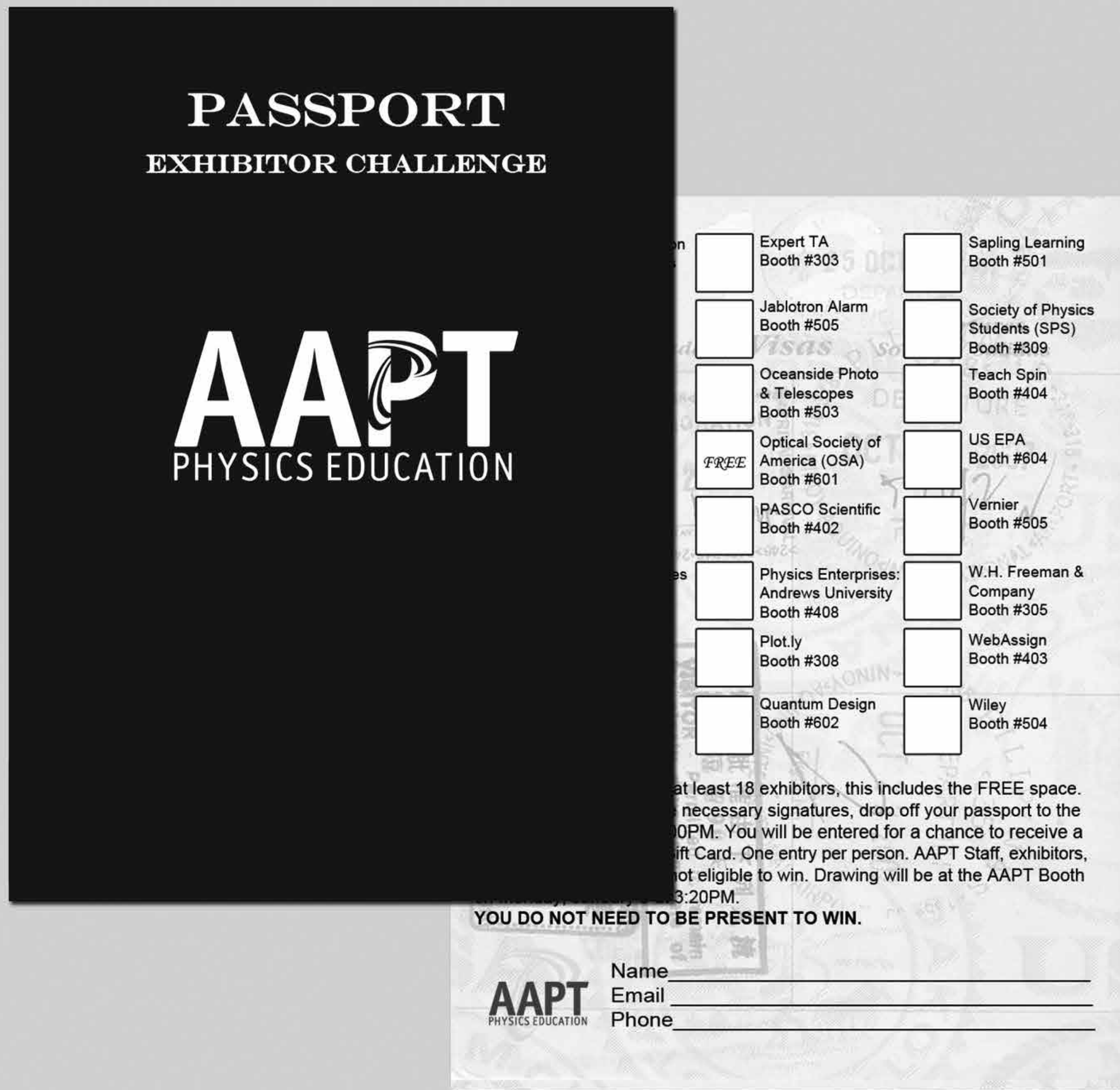
AAPT Welcome Reception and Exhibit Hall Opening

Sunday, July 26 • 8-10 p.m.

Stamp Student Union Grand Ballroom

EXPLORE THE EXHIBIT HALL FOR YOUR CHANCE TO WIN A

$100 AMERICAN EXPRESS GIFT CARD



PICK UP YOUR PASSPORT TODAY!

Session AA: Astronomy in the Physics Classroom

Location: Jimenez Hall (JMZ) - 0105
Sponsor: Committee on Space Science and Astronomy
Date: Monday, July 27
Time: 8:30–10 a.m.

Presider: Richard Gelderman

AA01: 8:30-9 a.m. Space Imagery in the Physics Classroom at CUA

Invited – Frederick C. Bruhweiler, Department of Physics, Catholic University of America, 200 Hannan Hall, 620 Michigan Ave. NE, Washington, DC 20064; bruhweiler@cua.edu

We discuss two space imagery projects used in undergraduate courses at CUA. In a "hands-on" physics course designed for education majors, we use imagery from solar space missions, especially that of the Solar Dynamic Observatory. In this case, one has public Internet access, typically within an hour of when images were obtained. Available smartphone applications and supporting information have further increased the usefulness to students. By using simultaneous, multiple bandpass imagery, one can probe temperatures from 4000 K to 10,000,000 K. With these capabilities, the possible student activities are almost limitless. We describe a few activities in detail. In a second project, undergraduates, funded through a NASA grant, have designed, built, and flown an imaging experiment on a large NASA balloon from Ft. Sumner, NM. We briefly describe the status of that experiment and the benefits to the students.

AA02: 9-9:30 a.m. Studying Supermassive Black Holes with Time Domain Observations

Invited – Suvi Gezari, Department of Astronomy, University of Maryland, College Park, MD 20742-2421; suvi@astro.umd.edu

Dynamical studies of nearby galaxies have demonstrated that supermassive black holes (greater than a million times the mass of the sun) lurk in the nuclei of almost all galaxies. Surprisingly, the masses of these black holes appear to be tightly correlated with the mass of their host galaxy bulge. Studying the coevolution of black holes and galaxies over cosmic time is one of the hottest topics in astrophysics. I will highlight some novel ways in which we can probe the demographics of supermassive black holes (mass, spin, binarity) with time-domain observations. I will present results from our work with the recently completed Pan-STARRS1 Survey, and the exciting future potential at the beginning of the next decade of the Large Synoptic Survey Telescope.

AA03: 9:30-9:40 a.m. Motivating Mechanics Using Astronomy and Space Science: Physics from Planet Earth

Contributed – Joseph C. Amato, Colgate University, 13 Oak Dr., Hamilton, NY 13346; jamato@colgate.edu

Enrique J. Galvez, Colgate University

The foundations of classical mechanics were laid down by Galileo and Newton to explain the motions of the Earth, Moon and planets, and to comprehend our place within the cosmos. These same goals are used to enrich and invigorate Colgate's introductory calculus-level mechanics course. Milestone discoveries (e.g., Hipparchus' measurement of the Earth-Moon distance, Kepler's laws, Newton's law of Universal Gravitation, Hubble's law) inspire the study of physics while illuminating the human aspect of scientific progress. Breaking-news events (e.g., the discovery of exoplanets, dark matter and energy; interplanetary spaceflight; the landing of Philae) enliven traditional topics and demonstrate that a basic understanding of mechanics is sufficient to appreciate many of the breathtaking discoveries of our day. The course has an associated textbook, entitled Physics from Planet Earth. Examples from the text (including exercises and homework problems) which use astronomy and space science to illustrate physical concepts are presented.

Monday, July 27 Highlights

High School Physics Teachers Day

REGISTRATION:
7 a.m.–5 p.m. — SSU - Foyer

First Timers' Gathering:
7–8 a.m. — SSU - Prince George's

Guest / Spouse Gathering:
9–10 a.m. — SSU - Crossland

Exhibit Hall Open:
10 a.m.–5 p.m. — SSU - Grand Ballroom

- –H.S. Physics Photo Contest Voting — Ballroom Lounge
- –H.S. Physics Teachers Resource Booth — Booth 323
- –PIRA Resource Room — Ballroom Lounge
- –Two-Year College Resource Room — Nanticoke
- –Monday Morning Raffle 10:15 — Grand Ballroom
- –Monday Afternoon Raffle 3:45 — Grand Ballroom

AAPT TEACHING AWARDS, DSCS:
10:30 a.m.–12 p.m. — SSU - Hoff Theater

Early Career Professionals Speed Networking:
12–1:30 p.m. — Physical Sciences Complex Foyer

High School Teachers' Day Luncheon:
12–1:30 p.m. — SSU - Prince George's

SPS Awards Reception:
6–7:30 p.m. — Physical Sciences Complex Foyer

Commercial Workshops:

– PASCO	9–10 a.m.	Margaret Brent A
– Sapling	9–10 a.m.	Margaret Brent B
– Perimeter	9–10:30 a.m.	Prince George's
– It's About Time	9:30–10:30	J. Ramon Jimenez
– The Expert TA	12–1 p.m.	J. Ramon Jimenez
– Perimeter	12–1 p.m.	Atrium
– Physics 2000	12–1 p.m.	Margaret Brent B
– WebAssign	1:30–2:30	Margaret Brent B

Committee Meetings, 6:15–7:30 p.m.

- –Apparatus — Charles Carroll A
- –Physics in High Schools — Atrium
- –International Physics Education — Margaret Brent A
- –Professional Concerns — Pyon Su
- –Space Science and Astronomy — Crossland

APS PLENARY, JAMES GATES
7:30–8:30 p.m. — SSU - Hoff Theater

Poster Session
8:30–10 p.m. — SSU - Colony Ballroom

AA04: 9:40-9:50 a.m. Using Radio Telescopes to Teach Physics

Contributed – Donald Andrew Smith, Guilford College, 5800 W. Friendly Ave., Greensboro, NC 27410; dsmith4@guilford.edu

Rexford Adelberger, Guilford College

I will present a lesson plan for incorporating small radio telescopes (SRTs) into the physics classroom. The SRTs allow one to address wave topics, including FFT analysis of sound, light, and radio signals as one coherent package. The SRTs are operated in real time over an Internet connection, enabling students to observe live at any time of day (or weather). This curriculum has been developed through outreach to local grade and middle schools and has also been used in the undergraduate laboratory, both for physics majors and non-majors. Students first learn how to interpret sound spectra through FFT graphs. Then they explore light spectra, and finally, they use our SRTs to observe the 21 cm emission like from HI clouds. From these observations, they learn that we are in the Galaxy, and that the Galaxy is rotating (and not as a rigid object).

AA05: 9:50-10 a.m. Invoking Astronomy Research Within Physics Classrooms: Extrasolar Planets & Black Holes

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

Examples from current astronomical research provide unique motivation for the teaching of physics. In our students' lives, we have gone from knowing only of our own system of planets to the discovery of over one thousand other stars with planets. These extrasolar planetary systems are motivating examples of introductory level mechanics. Students can apply basic physical principles to derive the properties of planets orbiting other stars. More excitingly, students can collect their own data and experience firsthand the fundamentals of astronomical observation and data analysis.

Session AB: History of Physics in Other (non-European) Cultures

Location: Jimenez Hall (JMZ) - 0220
Sponsor: Committee on History and Philosophy in Physics
Co-Sponsor: Committee on International Physics Education
Date: Monday, July 27
Time: 8:30–10 a.m.

Presider: Michael Ponnambalam

AB01: 8:30-9 a.m. History of Physics in India

Invited – Shiladitya Chaudhury, Auburn University, Office of the Provost, Auburn, AL 36849; schaudhury@auburn.edu

The history of physics in pre-colonial India is best captured by thinking about science as only one form of cultural expression. The ancient texts such as the RigVeda speak of a tripartite and recursive world view that profoundly influenced the development of Indian science along lines that deviate from Western thought as originated with the Greeks. The universe is viewed as three regions of earth, space, and sky which in the human being are mirrored in the physical body, the breath and the mind. The universe is connected to the human mind, which leads to the idea that introspection can yield knowledge. Understanding the nature of consciousness is a prominent feature of the Vedic view but this did not mean that other sciences were ignored. In this talk I will draw upon multiple secondary sources, including the writings of Subhash Kak, to describe some ideas such as an extremely old and cyclic universe, an atomic world and subject/object dichotomy, and relativity of space and time that would resonate with modern physicists. As an example, in the Vaisesika system atoms combine to form different kinds of elements which break up under the influence of heat. The molecules come to have different properties based on the influence of various potentials. The creativity and expansive world view of ancient Indian seers also allowed them to imagine developments centuries before their technological counterparts.

AB02: 9-9:30 a.m. Physics in Brazil: An Overview of Its History*

Invited – Olival Freire, Universidade Federal da Bahia, Campus de Ondina s/n Salvador, BA 40210340 Brazil; freirejr@ufba.br

The first modern astronomical observations in Brazil were performed by Stansel in Salvador and by Marcgrave in the Dutch Recife. Stansel's observations were used by Newton. Following the escape of Portuguese royal family to Brazil, early 19th century, engineer courses were opened offering training in mathematics and physics. The Observatorio Imperial was founded in Rio de Janeiro. The watershed, however, happened in the 1930s in São Paulo. Wataghin and Occhialini trained researchers for making innovative research in cosmic rays, including Lattes. After WWII new institutions were created and students went abroad to PhD studies. Bohm and Feynman spent time and Beck moved to Brazil. The 1964 military dictatorship interfered with physics in contradictory manners. Leaders, such as Lopes, Schönberg and Tiomno were persecuted. There was an increase in funds for science, the universities were reformed, and graduates studies created. Current Brazilian physics was shaped from the 1930s to the 1970s.

*Work supported by CNPq-CAPES

AB03: 9:30-10 a.m. History of Nuclear Physics in Japan Before 1945

Invited – Ekaterina Michonova-Alexova, Erskine College, 2 Washington St., Due West, SC 29639-0338 emichon@erskine.edu

Nuclear physics was one of the most advanced fields for Japanese physics between the beginning of the 20th century and the end of the World War II. But was Japan, the only country that experienced the devastating impact of the first atomic bombs, involved in nuclear research with applications to nuclear weapons, as multiple publications speculate? We review the nuclear physics development before the end of World War II, including all aspects of nuclear research in Japan. Beginning from Hantaro Nagaoka, the author of an early atomic model, which was referred to by Rutherford in his gold foil experiment, and emphasizing Yoshio Nishina, the father of modern physics in Japan, approached by the Japanese Army and Navy regarding the possibility of developing a nuclear weapon program, we summarize all publications regarding possible work on atomic bombs, in attempt to clarify the difference between evidence supported work and speculations.

Session AC: Increasing Access to Grad School

Location: Art-Sociology Building (ASY) - 2203
Sponsor: Committee on Diversity in Physics
Date: Monday, July 27
Time: 8:30–9:50 a.m.

Presider: Daniel Smith

AC01: 8:30-9 a.m. CAMPARE and Cal-Bridge: Two Institutional Networks Increasing Diversity in Astronomy

Invited – Alexander L. Rudolph, Cal Poly Pomona, Department of Physics and Astronomy, 3180 West Temple Ave., Pomona, CA 91768-2557; alrudolph@cpp.edu

We describe two programs, CAMPARE and Cal-Bridge, with the common mission of increasing participation of groups traditionally underrepresented in astronomy, through summer research opportunities, in the case of CAMPARE, scholarships in the case of Cal-Bridge, and significant mentoring in both programs, leading to an increase in their numbers successfully pursuing a PhD in the field. In five years, the CAMPARE program has sent 49 students, >90% from underrepresented groups, to conduct summer research at one of 10 major research institutions in California and Arizona. Of the 21 students who have graduated since CAMPARE began, 12 are attending graduate school. The Cal-Bridge provides much deeper mentoring and professional development experiences to students from a diverse network of higher education institutions in Southern California. Cal-Bridge Scholars benefit from financial support, intensive, joint mentoring by CSU and UC faculty, professional development workshops, and exposure to research opportunities at the participating UC campuses.

AC02: 9-9:30 a.m. Looking Beyond the Status Quo: A New Approach to Diversity in Graduate Physics Education

Invited – Brian Beckford, American Physical Society, One Physics Ellipse, College Park, MD 20744; beckford@aps.org

Theodore Hodapp, American Physical Society

Across the board in physical sciences, students from statically underrepresented minority (URM) groups account for a small percentage of awarded graduate degrees. The American Physical Society (APS) has started a national effort to increase the number of URM students that gain access to graduate school and obtain PhD's in physics. The Bridge Program is focused on addressing current admission practices including the use of traditional measures that may limit the participation of URM students in graduate programs. This talk will present some data on current levels of representation, outcomes of using a cutoff measures like the GRE, and some holistic admission best practices.

AC03: 9:30-9:40 a.m. Graduate Admissions Practices: Are There Distinct Admissions Frameworks Amongst PhD Programs?

Contributed – Jacqueline Doyle, Florida International University, 11200 SW 8th St., CP 204, Miami, FL 33199; doylejackd@gmail.com

Geoff Potvin, Florida International University

Graduate admissions may play a critical role in the prospects for the future diversification of the physics community. Recently, in concert with the APS Bridge Program's efforts to build new pathways to graduate degrees for traditionally underrepresented students, a survey of graduate admissions directors was conducted to assess current admissions practices and to identify the values and possible strategies that institutions use in their admissions decisions. In total, over 150 PhD-granting departments participated in the survey. We use topological data analysis, a general technique for cluster identification and relation, on a set of 21 questions in which respondents indicated the importance of several different student criteria. We analyze the results in an attempt to find clusters in the data that would indicate the existence of distinct, identifiable admissions frameworks within graduate programs. We discuss the implications for our understanding of how institutions admit new graduate students.

AC04: 9:40-9:50 a.m. Graduate Resources Advancing Diversity with Maryland Astronomy & Physics

Contributed – Lora Price, GRAD-MAP, 6804 Good Luck Rd., Lanham, MD 20706; price.loram@gmail.com

Alex McCormick, GRAD-MAP

Graduate Resources Advancing Diversity with Maryland Astronomy & Physics (GRAD-MAP) strives to build strong ties with mid-Atlantic minority-serving institutions (MSIs) through seminars, forums, workshops, science discussions, and research. We connect promising MSI students with our graduate and faculty researchers at the University of Maryland, College Park. Our goal is to give underrepresented students the skills and experience to successfully pursue graduate degrees in physics and astronomy. We will present an overview of the program, some of the successes so far, and plans for the future. GRAD-MAP is supported by the Physics and Astronomy departments at the University of Maryland, College Park.

Session AD: Mechanics Modeling Meets the New AP Physics I

Location: John S. Toll Physics Building (PHY) - 1410
Sponsor: Committee on Physics in High Schools
Date: Monday, July 27
Time: 8:30–9:30 a.m.

Presider: Jon Anderson

AD01: 8:30-9 a.m. A Parallel Pathway to a Better Physics Course

Invited – David Jones, Florida International University, 11200 SW 8 St., Miami, FL 33199; djones@fiu.edu

After approximately 40 years, the Advanced Placement program (College Board) has put the algebra-based physics course through an entire course reform. The curriculum, test, and teaching and learning goals for students in the program have been dramatically changed from the previous (AP Physics B) course. The reform took 13 years to develop and this past academic year (14-15) is the first full year of the existence of AP Physics 1. The change has been quite an adjustment for all of the teachers and students involved in the program. However, for teachers that have been teaching physics using the modeling approach, the change has not been as difficult to manage during this first year of the AP Physics course reform. I will show how the AP Physics I course curriculum and course goals (inquiry, argumentation, and Science Practices) very nearly parallel the "modeling cycle" and the goals of teaching physics using the modeling method. I will also share some activities that support teaching the AP Physics 1 course.

AD02: 9-9:30 a.m. Curriculum and Pedagogy Coalesce: Modeling and AP Physics Become One

Invited – Marc Reif, Fayetteville High School, 607 N Walnut Ave., Fayetteville, AR 72701-3554; marc.pricereif@gmail.com

When I began teaching physics in the late 1990s, I thought of inquiry in AP physics as something that was added here and there, in order to spice things up a bit. Attendance at a modeling workshop in 2002 convinced me that inquiry, and the deep understanding it fostered, should be the basis for the course. However, modeling and the former AP Physics B curriculum were not a good fit. "Coverage" and depth were at war with each other. Years of practice led me to develop a compromise; models and the modeling cycle formed the basis for the core of the course, and coverage held sway over the rest. The introduction of the revised AP course has made modeling more than just one possible approach to the course. The concept of modeling and models is now integral to the course; it is, in fact, built in to the Curriculum Framework.

Session AE: PER: Examining Content Understanding and Reasoning I

Location: John S. Toll Physics Building (PHY) - 1412
Sponsor: AAPT
Date: Monday, July 27
Time: 8:30–10 a.m.

Presider: Beth Lindsey

AE01: 8:30-8:40 a.m. Developing Students' Metacognitive Knowledge About Salient Problem Features*

Contributed – Thanh K. Le, University of Maine, 120 Bennett Hall, Orono, ME 04469; thanh.le@maine.edu

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

Mila Kryjevskaia, North Dakota State University

Student reasoning in physics is often context dependent. A possible explanation is that salient features in physics problems may cue automatic and subconscious (System 1) reasoning. Students often accept these first-available responses without question and do not reflect on their reasoning processes, even when such processes are unproductive and preclude the use of relevant conceptual understanding. Metacognition, the monitoring and regulation of one's thinking, around these salient features has the potential to address such difficulties. As part of a broader effort to identify methods for improving student learning in physics by explicitly supporting and enhancing student metacognition, we are currently investigating an instructional intervention focused on the development of students' metacognitive knowledge about salient features and cued System 1 reasoning. In this intervention, students are guided to synthesize contrasting cases involving sample student responses and descriptive vignettes highlighting the targeted metacognitive knowledge. Preliminary data and emerging findings will be presented.

*This work is supported in part by the National Science Foundation under Grant Nos. DUE-1245313, DUE-1245999, and DUE-0962805.

AE02: 8:40-8:50 a.m. Investigation of Student Reasoning in the Context of Scaffolded Instruction*

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

MacKenzie R. Stetzer, University of Maine

Andrew Boudreaux, Western Washington University

Sara Julin, Whatcom Community College

Student-centered instruction can lead to strong gains in physics learning. However, even after targeted instruction, many students still struggle to analyze unfamiliar situations systematically. As a part of an ongoing investigation of student reasoning in the context of carefully designed, research-based scaffolded instruction, sequences of questions have been developed that allow for probing the relationships among conceptual understanding, reasoning, and intuition. Results from sequences of questions administered in the introductory calculus-based mechanics course will be presented. The dual process theory of reasoning will be applied to interpret the results. Implications for research and instruction will be discussed.

*This work is supported in part by the National Science Foundation under Grant Nos. DUE-1245999, DUE-1245993, DUE-1245313 and DUE-1245699.

AE03: 8:50-9 a.m. Physics Experts' Use of Contrasting Cases When Solving Novel Problems

Contributed – Darrick C. Jones, Rutgers University, Department of Physics and Astronomy, Piscataway, NJ 08854-8019; dcjones@physics.rutgers.edu

Eugenia Etkina, Rutgers University

Instruction that makes use of contrasting cases has been extremely successful. Furthermore, contrasting cases appear to be at the center of expert problem-solving strategies. Previously we have shown that physics experts make use of contrasting cases more frequently than any other epistemological or reasoning process resource. Gaining a deeper understanding of the function of these contrasting cases can help physics educators better incorporate contrasting cases into instruction. In this talk, we analyze the function of contrasting cases as a part of the problem- solving process of a group of physics experts as they solve a novel, challenging physics problem. We show how the ideas of variation theory can help us better understand the function of these contrasting cases and discuss how the knowledge gained through this analysis can inform the development of effective instruction.

AE04: 9-9:10 a.m. How Physics Tutorials Facilitate Students' Use of Argumentation in Small-group Discussion

Contributed – Ozden Sengul, Georgia State University, GSU 1 Park Place NE, Atlanta, GA 30302-3999; osengul1@student.gsu.edu

Laura Kiepura, Josh Von Korff, Georgia State University

Physics Education Research focuses on increasing student engagement and conceptual understanding, prompting different research groups to develop and use new teaching methods and materials in place of traditional ones. It is important for us to understand the basic features that present in course materials and their impacts on students' learning. As part of a project to identify successful teaching strategies in studio physics, we are exploring how physics tutorials help students taking algebra-based introductory physics develop conceptual understanding using argumentation in small-group discussion. In order to identify basic features of tutorials, we conducted a literature review and did content analysis of physics tutorials; then, we videotaped groups of students working through physics tutorials. We analyzed the transcriptions of the students' discussions and compared them to pre- and post-test results to understand how basic features facilitate students' use of argumentation and development of conceptual understanding

AE05: 9:10-9:20 a.m. An Observational Coding Scheme for Interactive Classroom Evaluations

Contributed – Noel Klingler, George Washington University, Department of Physics, Washington, DC 20052; feldman@gwu.edu

Gerald Feldman, Larry Medsker, Zoe Pierce, Sarah Benya, George Washington University

Collaborative group-learning environments, including studio-based or SCALE-UP instruction, have grown in popularity and implementation at a wide variety of institutions. We are engaged in a multi-institutional project aimed at studying the factors that contribute to the success of student-centered pedagogical approaches in algebra-based physics courses. In this regard, the GW group is specifically focusing on documenting instructor actions and student activities taking place in the classroom; thus, we have been conducting systematic observations and analyses of various classroom environments. Our data, recorded as a chronological series of codes in the Teaching Dimensions Observational Protocol (TDOP), reflect the time sequence and pedagogical characteristics of classroom events. We have used a PER evidence-based approach to choose an efficient set of codes and have applied these codes during many observations at GW as well as at our partner institutions. We present here our final list of TDOP codes and inter-rater reliability results from our field-testing of this code set.

AE06: 9:20-9:30 a.m. Exploring Student Learning Profiles in Algebra-based Studio Physics*

Contributed – Jarrad W.T. Pond, University of Central Florida, 4111 Libra Dr., Orlando, FL 32816-2385; jarradpond@gmail.com

Jacquelyn J. Chini, University of Central Florida

As part of a project to explore successful strategies for using studio methods, such as SCALE-UP, we explore self-regulatory abilities and learning approaches of students in said courses at three universities with varying student populations and differing success in studio-mode courses. We survey students using compiled questions from several existing surveys designed to measure student characteristics such as attitudes toward and motivations for learning, organization of scientific knowledge, experiences outside the classroom, and demographics. Here, we utilize clustering methods to group students into learning profiles to better understand the study strategies and motives of algebra-based studio physics students. We present results from first-semester and second-semester studio-mode introductory physics courses across three universities, totaling 11 classrooms with 10 different instructors. We identify several distinct learning profiles and evaluate demographic and concept inventory performance differences between them.

*This work is supported in part by the U.S. National Science Foundation under grant DUE-1246024 and grant DUE-1347515.

AE07: 9:30-9:40 a.m. Expert and Novice Judgments of Problem Difficulty from Previously Administered Exams

Contributed – Jose P. Mestre, University of Illinois at Champaign-Urbana, 309 Loomis Laboratory, 1110 Green St., Urbana, IL 61801; mestre@illinois.edu

Jason W. Morphew, University of Illinois at Champaign-Urbana

Witat Fakcharoenphol, Kasetsart University, Kamphaengsaen Campus, Nakhon Pathom, Thailand

The ability to judge the difficulty of physics problems has implications for both exam preparation and performance. Previous research has shown that students spend more time studying problems they judge as more difficult, but this strategy is effective only when these judgments match the normative difficulty of the questions. Little is known about how accurate instructors and students are at judging problem difficulty. We present data from two experiments where physics experts and introductory physics students predict which question of a pair taken from real exams is more difficult for the "typical student." In the first experiment we analyze whether the rationales given by physics experts are predictive of accurate judgments. In the second experiment we compare the accuracy of experts and novices in their judgments. We discuss the educational implications of our findings.

AE08: 9:40-9:50 a.m. Physics Learning Facilitates Enhanced Resting-State Brain Connectivity in Problem-Solving Network

Contributed – Jessica E. Bartley, Florida International University, 11200 SW 8th St., Miami, FL 33156-5336; jbart047@fiu.edu

Matthew T. Sutherland, Shannon M. Pruden, Eric Brewe, Angela R. Laird, Florida International University

Modeling how students think about physics is often measured via observation of students solving physics problems.[1] Functional magnetic resonance imaging (fMRI) may inform how these processes occur, but currently no neuroimaging studies have examined how students develop physics problem-solving skills. To provide insight into the neural nature of physics learning we examined resting-state functional connectivity (rsFC) in brain regions associated with problem-solving. Meta-analysis identified the left inferior frontal gyrus (IFG) as the region most consistently implicated across problem-solving tasks. Resting-state fMRI data were acquired pre/post instruction in eight undergraduate, first-time enrollees in introductory physics. Correspondence between post-instruction rsFC and meta-analytic results suggests a semester of university physics may facilitate enhanced recruitment of posterior brain regions involved in reasoning. Increased IFG-correlated activity from pre to post instruction indicates intrinsic brain connectivity may be modulated as a result of educational experience.

1. Reif et al, *Educ Psych* **17** (1982).

AE09: 9:50-10 a.m. Development of Pre-service Elementary Teachers' Science Self-efficacy Beliefs and its Relation to Science Conceptual Understanding

Contributed – Deepika Menon, University of Missouri - Columbia, 105 W Broadway Apt # 6, Columbia, MO 65203-3377; dm2qc@mail.missouri.edu

Troy D. Sadler, University of Missouri - Columbia

Self-efficacy beliefs that play a major role in determining teachers' science teaching practices have been an important area of concern for pre-service science teacher education. This mixed-methods study investigated the changes in pre-service elementary teachers' science self-efficacy beliefs and its relationship with changes in science content understandings in a specialized physics content course. Participants included 51 pre-service elementary science teachers enrolled in two term of the course. Data collection included implementation of Science Teaching Efficacy Belief Instrument-B (STEBI-B) and Physical Science Concept Test as pre- and post-test as well as semi-structured interviews, observations and artifacts. A pre-post, repeated measures multivariate analysis of variance (MANOVA) design was used to test the significance of differences between the pre- and post-surveys across time. Results indicated statistically significant gains in participants' self-efficacy beliefs, personal science teaching beliefs, and outcome expectancy beliefs. Additionally, a positive moderate relationship between science conceptual understandings and personal science teaching efficacy beliefs was found. Findings from qualitative analysis suggest that despite of the nature of prior science experiences pre-service teachers previously had, exposure to a specialized content course that integrates relevant content along with modeled instructional strategies can positively impact self-efficacy beliefs. One implication from this study is that instructors teaching elementary physics content courses could shape science experiences within these courses to potentially support pre-service science teachers' self-efficacy beliefs and confidence to teach in future.

Session AF: Photographic Techniques New and Old

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Apparatus
Date: Monday, July 27
Time: 8:30–9:50 a.m.

Presider: David Mauillo

AF01: 8:30-9 a.m. Nineteen Century Scientific Photography

Invited – Thomas B. Greenslade, Jr., Kenyon College, Department of Physics, Gambier, OH 43022; greenslade@kenyon.edu

The first two photographic processes, the paper negative and the Daguerreotype, were announced in 1839. By the early 1850's the first pictures of the moon were made, and 15 years later the first stereoscopic pictures of the moon were taken. The stereoscopic technique was pioneered by Charles Wheatstone. James Clerk Maxwell made the first color photographs, and Gabriel Lippmann won the Nobel Prize for his technique of making full color photographs using standing waves set up in photographic emulsions. In the last years of the century Frederic Ives, the inventor of the half-tone process for putting images onto the printed page, developed a technique for making full-color stereoscopic images using his Kromoscop process. And, in the last quarter of the century Wilson Bentley developed his technique of photographing snowflakes; the assertion that no two snowflakes are the same comes from his work.

AF02: 9-9:30 a.m. New Video Techniques for the Physics Lab–High Speed, Infrared

Invited – Paul M. Nord, Valparaiso University, 1610 Campus Dr., Valparaiso, IN 46383-5000; Paul.Nord@valpo.edu

Visual images overwhelm the other senses, pervade our language, and frame our thoughts. Modern video cameras provide an instant replay of physical events that are on the edge of human perception. Infrared cameras can extend our vision to longer wavelengths. Several consumer-grade cameras put 1000 frame per second video within budget. The small "action cameras" and even cell phones can now record video at hundreds of frames per second. Infrared cameras reveal thermal energy. This talk will explore some of the modern high-end consumer cameras, their prices and availability, their application to exploring physics, and their limitations.

AF03: 9:30-9:40 a.m. The Effect of Rolling Shutter on Video Analysis*

Contributed – Robert B. Teese, Rochester Institute of Technology, 54 Lomb Mem. Dr., Rochester, NY 14623; rbtsps@rit.edu

Most new video cameras have CMOS image sensors that exhibit the rolling shutter effect. This is analogous to a focal plane shutter that exposes the top of the image at a different time than the bottom of the image. It leads to a systematic error in the video analysis of objects that move vertically. I measured the amount of rolling shutter in several cameras. I found that for a typical camera at 30 frames/s the effect on the measurement of the acceleration of gravity can be over 10% if the falling object traverses the video vertically in 0.5 s or less. The effect can be reduced by capturing longer fall times, by analyzing both the upward and downward motion of a projectile, by treating the effect as a systematic error and including a correction for it in the analysis, or by other methods.

*Supported by NSF grants DUE-1122828 & DUE-1123118.

AF04: 9:40-9:50 a.m. Analysis of 'Daruma-otoshi' the Japanese Toy Using a High-speed Camera

Contributed – Yuki Yoshino, Tokyo Metropolitan Oume-Sougou Senior High School, 2-20-8 Kyounan-cho Musashino-shi, Tokyo 180-0023 JAPAN ; happy-orange-snowman@hotmail.co.jp*

Koji Tsukamoto Kashiwa-minami High School

When an object moves rapidly, another object placed on the aforementioned object is left behind. This phenomenon (e.g. "pulling a tablecloth") is well known as the effective demonstration to introduce inertia. In Japan, we have a traditional toy called "Daruma-otoshi" based on this phenomenon. While this phenomenon is typically connected with Newton's first law, it is illustrated in much greater detail in the second law(1). Previously, it was difficult to analyze these experiments due to a short duration of action time. Today, an inexpensive high-speed camera enables us to measure such a short duration of time(2). Using the measurement from the camera, we discuss this phenomenon along with the second law.

1. Evan Jones, "The tablecloth pull," *Phys. Teach.* **15**, 389 (1977).
2. M.Vollmer and K.-P Mollmann, "Removing Coins from a Dice Tower: No Magic - Just Physics," *Phys. Teach.* **51**, 212-213 (2013)

*Sponsored by Koji Tsukamoto

Session AG: PIRA Session: Biophysics Demos and Apparatus

Location: SSU - Benjamin Banneker B
Sponsor: Committee on Apparatus
Date: Monday, July 27
Time: 8:30–9:40 a.m.

Presider: Steve Narf

AG01: 8:30-9 a.m. Thirteen Ways of Teaching Introductory Physics Using a Force Plate

Invited – James Reardon, University of Wisconsin-Madison, 1150 University Ave., Madison, WI 53706; jcreardon@wisc.edu

A force plate is a sort of technologically evolved bathroom scale. Typical units found in classrooms can measure forces of thousands of Newtons with resolution of 1 Newton, and time resolution of 1 ms, and cost less than $500. Some units can measure force components in two dimensions simultaneously. Classroom force plates are rugged enough that people can jump on them. Students can learn a lot of physics by jumping on force plates. In this talk I will describe 13 exercises that you can use to introduce students to force, momentum, and impulse, that are suitable for use as demonstrations or as laboratories. Introductory exercises bring sports into the classroom to help introduce students to physics; a few more advanced exercises are included in which students use their knowledge of physics to learn more about sports.

AG02: 9-9:30 a.m. Adapting Physics Lessons to the Life Sciences

Invited – Kenneth J. Lonnquist, Colorado State University, 1875 Campus Delivery, Fort Collins, CO 80523; kennlonnquist@gmail.com

In our two-semester general physics course, nearly 100% of the students are from life science majors. The needs of this student population vary considerably from those seeking a degree in physics or engineering. Over the last several years, we have been tailoring our physics labs to make solid connections with the material they have seen in their other courses. I will present several lab activities designed to approach topics these students have seen before, and often know quite well, but from a physics point of view in order to enrich their understanding of both the life science topics and the physical principles involved.

AG03: 9:30-9:40 a.m. Pressure in the Human Body: Physics of the Respiratory System

Contributed – Nancy L. Donaldson, Rockhurst University, 1100 Rockhurst Rd., Kansas City, MO 64011; nancy.donaldson@rockhurst.edu

This NSF-funded curriculum is a hands-on, active learning module covering the mechanics of breathing and the pressure differences in the body that guide air flow in the respiratory system in health and disease. The target learning audience is intermediate-level undergraduates, i.e., students who have already had a one-year introductory-level physics course; however, with the appropriate student background, it could be used in an Introductory Physics for the Life Sciences course. The module activities address Pre-Health Competency E3 (Demonstrate knowledge of basic physical principles and their applications to the understanding of living systems) and Foundational Concept 4B (Importance of fluids for the circulation of blood, gas movement, and gas exchange) and are directed toward an application of physics to medicine. Students particularly interested in these activities may be those pursuing graduate school/careers in medicine, health care, or medical physics or those interested in broadening their understanding of applications of physics.

Session AH: Teaching Sustainability in the Majors Curriculum

Location: SSU - Charles Carroll A
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 27
Time: 8:30–10 a.m.

Presider: Juan Burciaga

AH01: 8:30-9 a.m. Physics of Sustainable Energy for Physics Majors

Invited – David Hafemeister, Cal Poly University SLO, Physics Department, San Luis Obispo, CA 93407; dhafemei@calpoly.edu

The oil embargo of 1973 was a tipping point that radically changed public views on energy supply and demand. Many physics educators responded with calculations and new courses. Six months after the start of the embargo, Cal Poly introduced Physics 310, The Physics of Energy. We believed that more quantification on energy situations, and the limits of these calculations, was needed. The resultant back–of–the–envelope calculations have been gathered together in a text.[1] In this talk, we will focus on sample calculations dealing with climate change and energy in buildings. Over the years we developed a hands-on energy lab, especially intended for the architecture majors (Cal Poly has 1500 of them!). This year I am combining forces with the next generation, Pete Schwartz.[2] I will report back on how we combined the flipped classroom with tell'um–and–test'um. A secondary aim is to attract more tenured full professors into applied work on the physics of energy, following in the footsteps of such leaders as Art Rosenfeld, Rob Socolow and Dan Kammen. All have shown the very positive and far-felt impact that our profession can have. The Forum on Physics and Society has held three workshops at University of California at Berkeley on the Physics of Sustainable Energy: Using Energy Efficiently and Producing it Renewably.[3]

1. D. Hafemeister, *Physics of Societal Issues: Calculations on National Security, Environment and Energy,* Springer, 2nd ed., (2014).
2. P. Schwartz introduces material primarily through videos for his classes related to Energy, to Appropriate Technology, and to Freshman Introductory Physics. These videos are open to all at http://sharedcurriculum.wikispaces.com/
3. *Physics of Sustainable Energy,* American Institute of Physics Conference Proceedings 1044 (2008), 1401 (2011), 1652 (2015).

AH02: 9-9:30 a.m. Sustainability and Physics: A Perfect Match?

Invited – Bennet B. Brabson, Indiana University, Physics Department, Swain West, 727 E. Third St., Bloomington, IN 47405-2618; brabson@indiana.edu

Nearly 40 years ago Robert Romer at Amherst College wrote an introductory physics textbook called Energy An Introduction to Energy. As a new teacher of introductory physics at Indiana University, I was shocked to find that my first year physics course was not only fun to teach but that it was also useful. Basic physics is really good stuff! You really don't have to wait to finish your PhD before doing physics. Romer's beginning physics text was posing really important real world questions. Romer also convinced me that there is indeed a good match between physics and the broad field of sustainability. It's good to remember that physics contributes directly to most areas of science. At Indiana University we have developed an upper-level physics course called environmental physics. The course centers around forms of energy and solves problems ranging from nuclear energy to climate change. It reminds us physicists that the world is full of critical problems that are within our reach.

AH03: 9:30-10 a.m. Sustainability in the Physics Curriculum

Invited – Barbara Whitten, Physics Department, Colorado College 14 E. Cache la Poudre, Colorado Springs, CO 80903-3294; bwhitten@ColoradoCollege.edu

The proliferation of "Sustainability across the Curriculum" programs has offered physics departments an opportunity to think about what physics can contribute to sustainability. There are several topics where we have much to offer, for example Energy and Atmospheric Science. Our expertise in problem solving and a quantitative analysis can also be a useful contribution to interdisciplinary groups approaching problems in sustainability. I will present some general thoughts about topics in sustainability, and how each might fit into a physics curriculum. I will also discuss some specific projects that I have implemented in physics classes.

Session AI: Technology in the Physical Science Classroom

Location: SSU - Charles Carroll B
Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on Educational Technologies
Date: Monday, July 27
Time: 8:30–10 a.m.

Presider: Jan Mader

AI01: 8:30-9 A.M. Useful Apps for the Physics Classroom

Invited – Patrick Callahan, PTRA ,3537 Station Ave., Center Valley, PA 18034; ptcallahan@aol.com

David McCachren, PTRA

Smart phones, tablet computers, iPads and iPhones are available and used by most students today. There are a wide variety of apps being produced that allow physics teachers to bring this technology into the classroom as a tool to help students to learn physics. As a result of our experiences at PTRA Leadership Institutes, PTRA workshops presented for the Central PA Section of AAPT, and informal communications with other active teachers, we have catalogued the experiences of many teachers on their use of apps in the classroom. This session will provide a summary of apps that have been found useful and how they can be incorporated in the classroom. Copies of the presentation will be made available at aaptptra.com.

AI02: 9-9:30 A.M. Paperless Physics Day with Google/Apps

Invited – Michael Strange, Kennedale High School, 901 Wildcat Way, PO Box 1208, Kennedale, TX 76060; strami@me.com

Making Physics Day Easy and Fun again, with Quizzes/Grading all from a phone! We have successfully turned our local waterpark into a paperless physics classroom wonderland! We will show you videos/examples of student work during the physics day event and the preparation necessary prior to the event. We will walk you through google forms (quizzes) and how add-ons will automatically grade student responses and more. Participants may want to have the following iPhone/iPad apps to help collect speed/acceleration data: Speedclock, Sparkvue, and Video Physics.

AI03: 9:30-9:40 a.m. Learn About the 3D Printer in Your Future

Contributed – Dale Freeland, Portage Central High School, 8135 South Westnedge, Portage, MI 49002; dfreeland@portageps.org

My son and I assembled two Delta model 3D printers during a July 2014 four-day workshop sponsored by Square One Education Network at Michigan Technological University. My students and I used those 3D printers during the past school year. Students designed, printed, and improved parts utilized in engineering contest projects. Parts were printed for Science Olympiad engineering projects, for Underwater Remote Operated Vehicle contests, and for some equipment needed in lab and classroom. First-year physics students were given a challenge that involved CAD design and 3D printing of a part to meet the challenge. I will share some of those projects highlighting some of our challenges and successes. Based on high student interest and enthusiasm, I am predicting that there will be a 3D printer in your near future.

AI04: 9:40-9:50 a.m. Electricity and Magnetism Mini-Lessons Using Screen Capture

Contributed – Tetyana Antimirova, Ryerson University, 350 Victoria St., Toronto, ON M5B 2K3, Canada; antimiro@ryerson.ca

The screen capture technologies utilized in the tablet PCs opened up new exciting opportunities in an undergraduate science teaching since they allow capturing the reasoning, writing and drawing (with the audio component that can be recorded simultaneously or added later). The entire reasoning process can be exposed and problem-solving process can be recorded in a form of short videos. These videos can be uploaded into the courses management system, where the students can access them on demand as many times as needed. We created a number of mini-lessons targeting particularly difficult concepts in Electricity and Magnetism and demonstrating problem-solving strategies. Our mini lessons (shorter than 10 minutes) typically include a problem statement, detailed diagrams, questions to probe student initial knowledge, and derivations with detailed explanations. The scripts for the mini-lessons were developed by the students in the course. The examples of mini-lessons will be demonstrated.

AI05: 9:50-10 a.m. Data Analysis and Visualization

Contributed – Matt Sundquist, Plotly, 587A Dolores St., San Francisco, CA 94110; matt@plot.ly

Graphing is an essential component of science education. In this talk we'll demonstrate how to use Plotly, a free, online, interactive platform that allows students to visualize, analyze and explore data. Plotly is used by researchers at NASA, Google, the Center for Quantum Devices at the University of Copenhagen and thousands of teachers and students across the world.

Session AJ: Undergraduate Research and Capstone Projects I

Location: Art-Sociology Building (ASY) - 2309
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 27
Time: 8:30–10 a.m.

Presider: Aaron Titus

AJ01: 8:30-9 a.m. Management, Mentoring, Motivation, and Mayhem: Leading Large Groups of Students in Research

Invited – Jennifer L. Burris, Appalachian State University, Physics & Astronomy Department, Boone, NC 28608; burrisjl@appstate.edu

Brooke C. Hester, Appalachian State University

Leading large groups of students toward a common goal can be a challenge. Helping them achieve a high level of professionalism can be daunting. We utilize various software programs, apps, and data storage systems to keep track of everything: from student schedules, to grant proposals, to resumes. For any student planning to graduate, finding a great job or continuing their education is their priority. Mentoring students to achieve their goal requires them to market themselves, whether through their resume, social media, a cover letter, or an essay. I will share with you the tools we use to keep 20 research students organized and professional.

AJ02: 9-9:30 a.m. The Senior Project, Linchpin for a Successful Undergraduate Physics Experience

Invited – James Dugan, Hastings College, 800 N. Turner Ave., Hastings, NE 68901; jdugan@hastings.edu

Physics departments are continuously trying to improve their undergraduate programs. The improvement depends on what the department thinks are the most important skills needed by students. At Hastings College, a small private school in south central Nebraska, the focus is on experimental physics. With 10 of 12 classes having a laboratory, the students become very adept at putting systems together, making measurements and interpreting results. This gives the students a breadth of experience in many areas of experimental physics. The culmination of this lab-directed approach is the senior project, required of all majors. This year-long endeavor consists of two parts. In the fall semester the students pick the experiment, complete the research, and write a proposal. In the spring they purchase the materials, do the build, make the measurements and analyze the results. As part of this experience they present their results at a spring conference.

AJ03: 9:30-10 a.m. Hurricane Balls: An Undergraduate Project in Rigid Body Motion

Invited – David P. Jackson, Dickinson College, Department of Physics, Carlisle, PA 17013-2896; jacksond@dickinson.edu

David Mertens, Brett Pearson, Dickinson College

We present the details of a project on rigid-body motion that is appropriate as a capstone project in an upper-division classical mechanics course or as the basis for an independent student research project. The project consists of analyzing the motion of "Hurricane Balls," two metal spheres that are welded (or glued) together so that they act as a single object that can be spun like a top. The complex motion of Hurricane Balls provides a beautiful example of rigid-body motion in which the angular velocity and angular momentum are not aligned with each other. Fortunately, this motion is easy to reproduce and analyze experimentally and the theoretical analysis is more straightforward than the standard spinning top example that is discussed in most texts on classical mechanics. Furthermore, the excellent agreement between theory and experiment makes this an ideal project for undergraduates.

Session AK: Innovation and Entrepreneurship

Location: SSU - Atrium
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 27
Time: 8:30–9 a.m.

Presider: Randy Tagg

AK01: 8:30-8:40 a.m. Physical Computing: An Arduino-based Course for Artists and Scientists

Contributed – Jeffrey R. Groff, Shepherd University, PO Box 5000, Shepherdstown, WV 25443-5000; jgroff@shepherd.edu

A physical computer is a digital device that senses and interacts with the analog world. This talk will highlight a recently developed introductory physical computing course that aims to empower science and humanities students to create physical computers of their own conception by teaching them electronics and microprocessor programming using the Arduino open hardware and software ecosystem. Elements of the course pedagogy such as open-ended problem solving allow students to discover that many problems have multiple creative solutions. Meanwhile, end-of-semester projects aims to establish a collaborative marketplace of ideas in the classroom. While all students propose an idea for a physical computer to the class, the students themselves select a small number of these projects to be pursued and funded. Several example student projects will be shared.

AK02: 8:40-8:50 a.m. Preparing Students for Physics-Intensive Careers in Optics and Photonics

Contributed – Benjamin M. Zwickl, Rochester Institute of Technology, 84 Lomb Memorial Dr., Rochester, NY 14623-5603; benjamin.m.zwickl@rit.edu

Kelly N. Martin, Javier Olivera, Rochester Institute of Technology

Initial results will be described from an ongoing study that is investigating both academic and industrial career paths in optics and photonics. By grounding the discussion of workforce development in education research, we can have more productive discussions and a more accurate understanding of contentious topics such as skills gaps, shortages of skilled STEM workers, and similarities and differences between academic and industrial careers. The study is refining our understanding of the broad skills needed for success and how specific math, physics, and communication skills are utilized in academic and industrial labs. The information should inform physics departments seeking to link their curriculum with students' future careers and serve as a case study for linking physics education research with national priorities in workforce development.

AK03: 8:50-9 a.m. Practical and Design Knowledge for Physics-based Innovation

Contributed – Randall Tagg, University of Colorado, Physics Dept. CB 157, PO Box 173364, Denver, CO 80217-3364; randall.tagg@ucdenver.edu

The fundamental insights obtained through the study of physics are a good platform for innovation but they must be augmented by practical knowledge. Physics programs offer experiences with topics such as electronics and optics but these are highly variable and other key topics such as materials selection, structural design, motors, and control systems are likely presented in minimal ways if they are covered at all. This is a situation that is solvable through the creation of an "on-demand" learning framework through which students can gain a great sense of personal efficacy in connecting physics with a wide range of practical applications.

Session AL: Make, Play and Learn

Location: SSU - Atrium
Sponsor: Committee on Physics in Pre-High School Education
Co-Sponsor: Committee on Physics in High Schools
Date: Monday, July 27
Time: 9–10 a.m.

Presider: Bill Reitz

K-12 students can learn much by constructing their own apparatus and investigating the principles involved. A panel will kick off this round-robin Share-a-thon with "make & take" projects—along with the activities that make them powerful. Attendees are also highly encouraged to contribute their favorite activities. Bring sufficient materials and instructions to share with 25 other participants.

Cooperative Projects for Kids to Make, Play, and Learn

Panelists:

Steven Shropshire, Idaho State University

Mari Hayes, Russellville Public School

Paul Wolf, Haas Academy

Lesilie Embery, Apopka High School

For the last three years, ISU, the ISU SPS, the Pocatello Kiwanis Club, and other community organizations have teamed up to provide a Haunted Science Lab. The laboratory is a set of interactive science exhibits designed to entertain and educate first–ninth grade kids. The Lab has been open for one or more weeks each year for school field trips, with an average impact of 1000 kids per year. In conjunction with the field trips, after school teacher workshops and demonstration shows during school assemblies were provided. Part of each teacher workshop focused on construction activities and take-home experiments kids could do to extend the learning experience of our Haunted Science Lab. An overview of this program will be provided, along with highlights of other cooperative projects designed to offer fun opportunities for kids to make, play, and learn.

Awards Session: 2015 AAPT Teaching Awards; 2015 Homer L. Dodge Citations for Distinguished Service

Location: SSU - Hoff Theater
Date: Monday, July 27
Time: 10:30 a.m.–12 p.m.

Presider: Steven Iona

Dwain M. Desbien

David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching, 2015 – Dwain Desbien

Dwain M. Desbien, Division of Science & Mathematics, Estrella Mountain C.C., Avondale, AZ 85392; dwain.desbien@emcmail.maricopa.edu

Introductory Physics: What We Teach, How We Teach It, and What We Should Be Doing!

Much of what we teach in introductory physics is centuries old and how we have taught it has changed very little in the last 100 years. While this is not news to most members hearing this talk, the better question is why have things not changed? What changes can we and should we be making in our curriculum, in our departments, and in our institutions? Why has change been slow even though physics education research (PER) is clearly showing us things we should be modifying? While,I wish I had all the absolute answers to these questions, I will discuss and share some thoughts and suggestions on what and how we can affect changes in our departments and in the broader physics community.

Gillian E. Winters

Paul W. Zitzewitz Award for Excellence in Pre-College Physics Teaching, 2015 – Gillian Winters

Gillian E. Winters, Smithtown High School, St. James, NY 11780; gwinters@smithtown.k12.ny.us

Carpe Diem. Seize the Opportunity!

"Opportunity breeds success" is a statement that rings true both for students and for professionals. In general, students learn what they are taught, and some students manage to go beyond what they are taught in either depth or in breadth. Opportunities, however, can open up a whole universe to many students, where they can learn about things they would never have dreamed of, and environments in which they can thrive. Professionals, whether they are teachers or are in other disciplines, can have fulfilling jobs and careers. Opportunities can add dimensions to teachers' programs and excitement to teachers' careers. I will discuss some opportunities available to students, and examples of how some students have thrived in their new environments. In addition, I will discuss some opportunities available to high school teachers that have led to rewarding experiences and richer programs back in the classroom.

Homer L. Dodge Citations for Distinguished Service to AAPT

Kathleen A. Harper
The Ohio State University

Jill Marshall
The University of Texas at Austin

Marie Plumb
Jamestown Community College, Jamestown, NY, emerita

Scott F. Schultz
Delta College, University Center, MI

Albert Thompson
Ponderosa High School, Parker, CO, emeritus

TOP01: Topical Discussion: Solo PER Faculty

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Professional Concerns
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 27
Time: 12–1:30 p.m.

Presider: Eugene Torigoe

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 Topical Discussion 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.

TOP02: Topical Discussion: Web Resources for Teaching Astronomy

Location: SSU - Benjamin Banneker B
Sponsor: Committee on Space Science and Astronomy
Date: Monday, July, 27
Time: 12–1:30 p.m.

Presider: Kevin Lee

This topical discussion will look at several new astronomy offerings available on the Internet. Participants (who are encouraged to bring laptops, tablets, and smartphones) will then brainstorm in groups on how to best make use of these capabilities.

TOP03: Topical Discussion: Communication Difficulties with Students

Location: SSU - Charles Carroll A
Sponsor: Committee on Physics in Two-Year Colleges
Date: Monday, July, 27
Time: 12–1:30 p.m.

Presider: Kris Lui

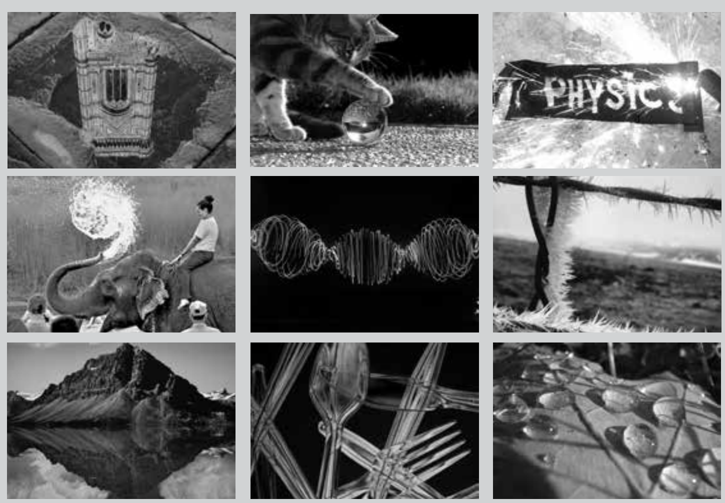
Innovative teaching techniques tend to make use of language, such as clicker questions, oral discussions, context-rich problems, etc. For students whose native language is not the same as instruction, students with anxiety, or have various accommodations, these techniques introduce additional complications. In this discussion, share your strategies and learn from your colleagues to help engage students from a wide variety of backgrounds.

TOP04: Update on the Work of the AAPT/APS Joint Task Force on Undergraduate Physics Programs

Location: SSU - Charles Carroll B
Sponsor: Committee on Physics in Two-Year Colleges
Date: Monday, July, 27
Time: 12–1:30 p.m.

Presiders: Robert Hilborn and Beth Cunningham

This session will focus on the guidelines and recommendations being developed by the AAPT/APS Joint Task Force on Undergraduate Physics Programs. J-TUPP is studying how undergraduate physics programs might better prepare physics majors for diverse careers. The guidelines and recommendations will focus on curricular content, flexible tracks, pedagogical methods, research experiences and internships, the development of professional skills, and enhanced advising and mentoring for all physics majors.



Session BA: Assessment Methods and Issues (Panel)

Location: Art-Sociology Building (ASY) - 2203
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Eleanor Sayre

BA01: 1:30-1:50 p.m. Student Evaluations of Instruction and Their Relation to Students' Conceptual Learning Gains

Panel – Warren Christensen, North Dakota State University, Fargo, ND 58105; Warren.Christensen@ndsu.edu

LaDoris Lee, Northeastern Illinois University

Melissa Dancy, University of Colorado at Boulder

Charles Henderson, University of Western Michigan

At most universities, Student Evaluations of Instruction (SEIs) are often the primary metric used to evaluate the quality of an instructor. Although SEIs are reflective of student attitudes towards the class, it is not clear to what extent SEI scores represent the extent to which students learned content in the course. Faculty volunteers, who were recruited from a pool of recent attendees of the APS's New Faculty Workshop, were utilized to shed light on this important issue. A broader study of faculty by Henderson and Dancy allowed for the solicitation of numerous forms of class artifacts from these faculty including student evaluations of instruction and multiple-choice conceptual survey data. While this data might seem easy to come by, there is almost nothing in the literature that provides a strong signal about the correlation of these two metrics. The data indicate that there is no correlation between SEI ratings and normalized learning gains on the FCI, or other instruments. Thus, it appears that faculty receiving high (or low) evaluations from their students has no connection to how much conceptual understanding their students developed throughout the semester.

BA02: 1:50-2:10 p.m. Equity Perspectives and Attitude Shifts in Introductory Physics

Panel – Adrienne Traxler, Wright State University, 3640 Colonel Glenn Highway, Dayton, OH 45435-0001; adrienne.traxler@wright.edu

Beyond grades and conceptual gains, student attitudes and epistemologies provide an additional measure of success in physics courses. Unfortunately, students' measured attitudes typically become more negative or novice-like over their first semester, with some studies indicating a worse decline for women. I will discuss a pattern of positive attitudinal shifts recorded over seven years of Modeling Instruction courses at Florida International University. Disaggregated by gender and by ethnic representation, we find that gains are shared across student groups. I will discuss the equity implications of these results and contextualize them in the sometimes problematic area of "gap-gazing" studies.

BA03: 2:10-2:30 p.m. Two Decades of FCI and FMCE Gains: A Meta-analysis

Panel – Joshua S. Von Korff, Georgia State University, 25 Park Place, Room 605, Atlanta, GA 30350; jvonkorff@gsu.edu

Tyrel Heckendorf, Chase Shepherd, Georgia State University

Sarah B. McKagan, American Association of Physics Teachers

Eleanor C. Sayre, Kansas State University

The Force Concept Inventory and the Force and Motion Conceptual Evaluation are among the most widely used assessments in physics education research. Since the creation of these assessments, more than 50 papers have been published describing student gains by comparing pre-test and post-test data. We have collected and analyzed these papers, representing more than two decades of student data published in *Physical Review,* the *American Journal of Physics,* the PERC Proceedings, and other journals. This collection enables us to answer questions such as: how are gains affected by pre-test scores and SAT scores across multiple universities? Have reported gains historically increased, decreased, or stayed the same? What is the range of gains that can be expected for traditional vs. interactive engagement instruction? These results will be useful to teachers as well as researchers.

BA04: 2:30–2:40 p.m. Attempts at Synthesis

Panel – Scott Franklin, Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY 14623-5603; svfsps@rit.edu

Stamatis Vokos, Seattle Pacific University

Assessment is a core endeavor in educational research. The following quote (attributed to Einstein, probably incorrectly) serves as a pithy reminder of the issues we face. "Not everything that can be counted counts. Not everything that counts can be counted." We therefore try to match assessment methodology with our particular educational goals. As a discussant, I will attempt a synthesis of the themes that emerge from the previous three talks, paying special attention to feedback mechanisms that force us to reconsider features of and values embedded in our learning environments in view of assessment results.

Session BB: Developing Experimental Skills in the Laboratory

Location: Art-Sociology Building (ASY) - 2309
Sponsor: Committee on Laboratories
Date: Monday, July 27
Time: 1:30–3:20 p.m.

Presider: Mary Ann Klassen

BB01: 1:30-1:40 p.m. LEGO Physics – A Hands-on Approach to Improve Students' Confidence with Experiments

Contributed – Maria B. Parappilly, Flinders University, School of Chemical and Physical Sciences, Adelaide, SA 5001 Australia; maria.parappilly@flinders.edu.au

Susan G. Pyke Flinders, Christopher Hassam, Lina Aviyanti, Flinders University

Workshops using LEGO race cars were developed to allow students in a non-calculus based physics topic an introduction to laboratory experience. The voluntary workshop was offered to improve students' confidence with experiments especially in the uncertainty propagation calculation. LEGO activities were designed to give students' opportunities to present information in a laboratory report, to calculate uncertainties, to record work concisely and hence to help them build skills evaluating and analyzing experimental data. Students were invited to complete three activities using LEGO race cars. In one activity students used a LEGO car and five sets of different sized wheels to investigate the relationship between the wheel size and the speed of a car by measuring the time taken to travel a known distance. This study will be extended to more topics in 2015. Initial results of the pilot study and the usefulness of our approach will be described in this paper.

BB02: 1:40-1:50 p.m. Framework for Students' Epistemological Development of Physics Experiments

Contributed – Dehui Hu, Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY 14623; dxhsps@rit.edu

Benjamin M. Zwickl, Rochester Institute of Technology

In order to better understand the impact of lab courses and experiential learning on students' views of professional physics and physics careers, we are developing tools that assess students' epistemology specifically related to physics experiments. We have conducted a series of open-ended

individual interviews about doing physics experiments with students in various stages of academic study, from introductory-level physics courses to graduate research labs. The interviews were used to develop a more detailed framework of students' epistemology of experimental physics, which includes topics such as justifications for the validity of experiments, relationship between theory and experiment, autonomy in experimentation, and the role of uncertainty analysis. Based on the preliminary findings, we developed and administered an open-ended survey to a larger student population in order to more clearly identify key aspects of epistemological development from introductory physics students to graduate students.

BB03: 1:50-2 p.m. Replacing Lab Reports with Lab Notebooks: Developing and Assessing Authentic Scientific Communication Skills

Contributed – Jacob T. Stanley, Department of Physics, CU-Boulder Department of Physics, 390 UCB, Boulder, CO 80309-0390; jtstan@gmail.com

Dimitri Dounas-Frazer, Noah Finkelstein, Heather J, Lewandowski, Department of Physics, CU-Boulder

While lab reports are often the main communication and evaluation tool used in lab courses, they are not an authentic form of communication used by professional physicists. We no longer require students to write traditional lab reports in our junior-level electronics lab. Instead, students document their work in a lab notebook, a more authentic form of scientific communication. We present results from our analysis of students' notebooks, including a comparison of the characteristics of notebook entries written during guided lab experiments with those from the open-ended project portion of the course.

BB04: 2-2:10 p.m. Structuring the Lab Report

Contributed – Stephen March, 605 Good Springs Rd., Brentwood, TN 37027; steve@marchco.net

This year, my team and I have standardized the lab reporting format throughout the levels of high school physics offered. At different grade levels, different scaffolding is used and scaffolding decreases as students progress through the grades. Introductory physics classes use lab reports with sentence frames and word blanks while upper-level physics classes use goal-oriented labs with students still required to report on the standard format. In this presentation, I will detail the standard lab format we developed and discuss the use of sentence frames for scaffolding the reporting structure.

BB05: 2:10-2:20 p.m. Student Understanding of Circuit Function: Does Scaffolding Help or Hurt?

Contributed – Evan Halstead, Skidmore College, 815 N. Broadway, Saratoga Springs, NY 12866-1632; ehalstea@skidmore.edu

Laboratory experiments generally fall into one of two categories: scaffolded—in which students are given a guided procedure—and non-scaffolded—in which students design their own experiment. Students in an electronics course for physics majors at a liberal arts college were randomly assigned to one of two groups for each lab during the semester. The scaffolded experimental group was given a circuit-building procedure with explicit step-by-step directions and question prompts, and the non-scaffolded experimental group was given the same task but with many of the procedural steps and prompts removed. In order to measure the effects of scaffolding, students completed a post-lab quiz designed to assess both recall of the lab as well as understanding of how the circuit would work with a hypothetical alteration. In this talk, I will present details of the curriculum as well as the experimental results.

BB06: 2:20-2:30 p.m. Engaging Students in Scientific Practices in an Electronics Course

Contributed – Heather Lewandowski, University of Colorado, CB 440 Boulder, CO 80309; lewandoh@colorado.edu

Noah Finkelstein, Dimitri Dounas-Frazer, University of Colorado

There are a tremendous number of goals for the undergraduate curriculum related to experimental physics.[1] Meeting these goals is typically the responsibility of an Advanced Lab course. Often, this Advanced Lab course lasts only one semester and requires considerable resources. To complement learning that is traditionally associated with the Advanced Lab, we have transformed our junior-level electronics course to engage students in authentic scientific practices and meet many of the undergraduate experimental physics goals--an approach that uses significantly fewer resources than our Advanced Lab. We describe our framework for incorporating authentic scientific practices in an electronics course and present initial outcomes from the project.

1. AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum, http://www.aapt.org/Resources/upload/LabGuidlinesDocument_EBendorsed_nov10.pdf

BB07: 2:30-2:40 p.m. Cross Disciplinary Skills in a Biology Focused Introductory Course

Contributed – Mark E. Reeves, George Washington University, 725 21st St. NW, Washington, DC 20052; reevesme@gwu.edu

A small group of biology, biophysics, and computer science faculty have worked together for the past five years to develop curricular modules (based on SCALEUP pedagogy). Laboratories are taught in the same classroom as concepts are tested and more theoretical aspects of problem solving are practiced. This has enabled students to create multi-representational models of models of stochastic and deterministic processes. We find that students are challenged by asking them to think across disciplinary boundaries, but more fundamentally, the introductory students find that simultaneously describing observed phenomena in a multi-representational framework is helpful. Our students are first-year engineering and science students in the calculus-based physics course and they are not expected to know biology beyond the high-school level. In our class, they learn to reduce complex biological processes and structures in order to model them mathematically to account for both deterministic and probabilistic processes. The students test these models in simulations and in laboratory experiments that are biologically relevant such as diffusion, ionic transport, and ligand-receptor binding. Moreover, the students confront random forces and traditional forces in problems, simulations, and in laboratory exploration throughout the year-long course as they move from traditional kinematics through thermodynamics to electrostatic interactions.

BB08: 2:40-2:50 p.m. The Challenge of Developing Experimental Skills in an Introductory Lab with Transient Temporary Instructors

Contributed – Robert A. Cohen, East Stroudsburg University of Pennsylvania, 200 Prospect St., East Stroudsburg, PA 18301; rcohen@esu.edu

John K. Elwood, East Stroudsburg University of Pennsylvania

After much trial and error, we've developed an introductory laboratory sequence for the first semester of our algebra-based sequence that focuses on the analysis and interpretation of data within the context of the topics and concepts addressed in the course. The main challenges have to do with the mathematical competency of the students, the number of students in each lab and the lack of continuity in regards to the instructors. We'll detail the challenges, discuss how we addressed them, and describe the challenges that remain.

BB09: 2:50-3 p.m. Measurement Fundamentals

Contributed – Grey M. Tarkenton, Applied & Computational Physics, LLC 263 Summit Dr., Bailey, CO 80421; comtneer97@gmail.com

Overcoming the "physics labs don't work" impressions of introductory lab exercises is important to establishing the empirical basis of the science. This can be accomplished relatively easily by emphasizing a few basic points and reiterating them in the classroom, the lab and during homework. We review these basic points in this presentation and offer a number of demonstrations and lab techniques to reinforce them.

BB10: 3-3:10 p.m. Gearing Up for Labs in High School Physics

Contributed – Beverly T. Cannon, Kathlyn Gilliam Collegiate Academy, 1700 East Camp Wisdom Rd., Dallas, TX 75241; cannonb75@gmail.com

The influx of technology can mask the skills that students really need to understand lab analysis. At the opening of school, schedule changes and late arrivals can interfere with the beginning lab exercises. I have used a simple lab for data gathering and analysis strategies to introduce the process for physics labs. The plan includes the gradual introduction of data gathering equipment to improve the data collection. This also makes an excellent reference lab for future work.

BB11: 3:10-3:20 p.m. Communication Capability Construction in the Experimental Courses*

Contributed – Han Shen, School of Physics and Engineering, 135. Xingangxi Rd., Haizhu District, Guangzhou, 510275 China; stszfl@mail.sysu.edu.cn

For the physics experiment course the purpose includes the abilities of reading the background materials in order to find the procedure of the experiment, thinking the design idea of the experiment and the error control, measuring the corresponding physical data and analyzing the data obtained from the experiment and presenting the result of the experiment. In our course instructions, we introduced the communication capability construction. We have changed the common homework, the experimental report, into three kinds of homework. They are the simplified report, complete report, poster and academic abstract. By the detail guidance of the four kinds of homework, the students may build a better background for further physics experimental studies which relate the academic projects and the academic research assistant works.

*This work was supported by NSFC-J1103211, 1210034.

Session BC: Digital Library Resources for Teaching Physical Science

Location: Jimenez Hall (JMZ) - 0105
Sponsor: Committee on Educational Technologies
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Bruce Mason

BC01: 1:30-2 p.m. The Chemical Education Digital Library: Online Resources for All

Invited – John W. Moore, University of Wisconsin-Madison, 1101 University Ave., Madison, WI 53706-1380; jwmoore@chem.wisc.edu

Would you be interested in an interactive, online periodic table that includes pictures of the elements, videos of their reactions, 3-D models of their crystal structures, physical and atomic-level data, and the means for sorting and graphing those data? This is Periodic Table Live! It is only one of the many online resources available from the Chemical Education Digital Library (ChemEd DL), a collaboration of the American Chemical Society, the Journal of Chemical Education, and the ChemCollective project at Carnegie-Mellon University (http://www.chemeddl.org/). Other examples of learning materials are Molecules 360, molecular structures in JMol format; ChemTeacher, an annotated collection of online resources keyed to the typical high school chemistry curriculum; ChemPRIME, a general chemistry textbook in wiki format from which students can learn chemistry in the context of other sciences, everyday life, or other areas of interest; and ChemPaths, a means of ordering the content of the ChemPRIME textbook, presenting it to students, and allowing them to deviate from the path but easily find a way back. These and other ChemEd DL resources will be demonstrated.

BC02: 2-2:30 p.m. InTeGrate, K-12 Portal, Pedagogies in Action and More: Resources from SERC

Invited – Sean Fox, Carleton College, 1 N College St., Northfield, MN 55057; cmanduca@carleton.edu

Cathryn Manduca, Krista Larsen, Carleton College

Teaching at any level is most effective when it brings together a strong mastery of the content, expertise with classroom pedagogies, and a supportive institutional framework. Resources at the Science Education Resource Center (SERC) span that range for teachers of physical science. The InTeGrate project website, which focuses on teaching science in the context of societal issues, includes information on strategies for interdisciplinary teaching, materials for science methods courses, and strategies for supporting student academic success. Topical resources include engineering and the Earth, risk and resilience, groundwater flow, the critical zone and more. The K-12 portal draws across 74 projects hosted by SERC to feature resources for K-8, 9-12, and AP/IB teachers across the science disciplines. The Pedagogies in Action site links information on pedagogies with examples of their use and includes a physics specific portal developed in collaboration with ComPADRE.

BC03: 2:30-3 p.m. PhysPort: Supporting Physics Teaching with Research-based Resources

Invited – Sarah McKagan, American Association of Physics Teachers ,1810 E Republican St #7, Seattle, WA 98112; sam.mckagan@gmail.com

Physics education researchers have created research results, teaching methods, curricula, and assessments that can dramatically improve physics education. PhysPort (www.physport.org) is a one-stop shopping place for ordinary physics faculty to find resources for research-based teaching and assessment. First released in 2011 as the PER User's Guide, PhysPort has undergone re-branding, redesign, and expansion, including many new resources: overviews of over 50 research-based teaching methods and over 40 research-based assessment instruments, Expert Recommendations, the Virtual New Faculty Workshop, the Periscope collection of video-based TA training and faculty professional development materials, and the Assessment Data Explorer, an interactive tool for faculty to get instant analysis and visualization of their students' responses to research-based assessment instruments including the FCI, BEMA, and CLASS, and compare their results to national averages and students like theirs. The development of PhysPort includes research to determine faculty needs and usability testing to ensure that we meet those needs.

BC04: 3-3:30 p.m. Lessons Learned from The Math Forum

Invited – Stephen Weimar, The Math Forum, 3210 Cherry St., Philadelphia, PA 19104-2713; steve@mathforum.org

A presentation on the ways in which The Math Forum supports learning and teaching math through online interactions that engage students, facilitate the development of the Mathematical Practices, and support formative assessment. We will discuss the professional development and research that is built around students' mathematical thinking.

Session BD: First Year Physics Teachers: Insights & Experiences

Location: Jimenez Hall (JMZ) - 0220
Sponsor: Committee on Teacher Preparation
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Duane Merrell

Come listen to what new secondary physics teachers tell us about how we helped them prepare to be high school physics teachers. Find out if we are missing something in the preparation of secondary physics teachers or if there is something they believe we should add to what we do in secondary physics teacher preparation.

BD01: 1:30-3:30 p.m. Journey from Graduate Studies to High School Physics: My Personal Reflections

Contributed – Jing Han Soh, Ceiba College, Prep 260 West Riverside Dr., Santa Cruz, CA 95076; jing.soh@ceibaprep.org

After three years in graduate school and working as a research assistant, I was recruited to teach at a high school. I will share my surprising and non-traditional journey in becoming a teacher and the experience being the first and only physics teacher in the school. Things that have helped in my preparation are -- 1) having a mentor in the same field through AAPT eMentoring Program; 2) having collaboration and professional development opportunities within the teachers community; and 3) the ability to bring real world practices into a classroom. I will also share my non-insights and difficulties as I navigate through the education world.

BD02: 1:30-3:30 p.m. Transitioning From a Community College Teacher to a Four-Year University Instructor

Contributed – James D. Rall, Northern Arizona University, 948 W Coy, Flagstaff, AZ 86005; james.rall@nau.edu

The transition from one teaching position to another can be very challenging especially when moving from a community college to a four-year university. Last year I made the transition from a community college small classroom atmosphere to a university with a large "Introduction to Physics" lecture class for non-majors. There are distinct advantages and disadvantages for teaching in these two different environments. The goal of my first year of teaching at a four-year university was to take the advantage of an interactive small classroom and apply it to a large class size. The different techniques for creating the small classroom feel in a large class size will be discussed along with other observed differences. Future plans toward this goal will also be introduced including the use of a flipped classroom.

Session BE: LHC in the Classroom

Location: SSU - Charles Carroll A
Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on International Physics Education
Date: Monday, July 27
Time: 2–3:30 p.m.

Presider: Ken Cecire

BE01: 2-2:30 p.m. LHC Masterclass: A Culminating Activity for Teaching Particle Physics

Invited – Jeremy Smith, 17301 York Rd., Parkton, MD 21120; jsmith10@bcps.org

Particle physics, though an esoteric field, nonetheless represents a high-interest subject for many students. Through the efforts of the QuarkNet collaboration, teachers have learned many ways to show students that it really is possible to understand particle physics, at least in part, merely by application of the conservation laws that they learn in introductory-level physics classes. QuarkNet's LHC Masterclass in the U.S. is part of a larger, worldwide effort to get more students interested in physics in general, and particle physics in particular. In this session, we will show teachers how the masterclass accomplishes this goal: first, by exposing students to particle physics concepts; second, by giving them the chance to view and analyze real data collected at CERN's Large Hadron Collider experiment; and third, by allowing students to collaborate with each other, with other schools, and with experts in the field through a summative videoconference.

BE02: 2:30-3 p.m. Teaching Particle Physics with LHC Data in AP Physics

Invited – Michael Fetsko, Mills E. Godwin High School, 2101 Pump Rd., Henrico, VA 23238; mrfetsko@henrico.k12.va.us

The discovery of the Higgs Boson at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland back in 2012 has brought particle physics into the minds of the general public and our students. As physics teachers, we need to seize upon this interest and bring high- energy physics into our classrooms. With the development of the AP Physics 1 and 2 courses, how is this possible? In this talk I will outline how I have incorporated particle physics into my classroom even with the new expectations placed on us through the new courses. This presentation will explain a variety of investigations that you can bring into your classroom using real particle physics data that has been released from the two big experiments at the LHC, ATLAS, and CMS. Through these investigations, your students will be able to examine real event displays, calculate invariant rest masses, create and analyze mass plots, and discover particle physics using the same data that researchers all over the world are using.

BE03: 3-3:10 p.m. A Classroom Look at the LHC

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

How do you engage students in the learning process? How do you get students to ask good testable questions? How do you get students to draw conclusions supported by data? My solution was to get the students involved with cutting edge research. Expose the students to data from the Large Hadron Collider. This a look at how LHC data and connections are used in my classroom and the responses that students have to this approach.

BE04: 3:10-3:20 p.m. A Spacetime-Constant Experiment Using Electrons

Contributed – Tavish L.E. Hill, University of Missouri-St. Louis, 503J Benton Hall, One University Blvd.. St. Louis, MO 63121-4400; tlhm94@umsl.edu

Philip Fraundorf, University of Missouri-St. Louis

One opportunity for students to discover an inherent connection between space and time is to measure a (finite) spacetime constant "c". Doing so without reference to the propagation of light waves can help teachers avoid improper conceptual scaffolding that often litters introductory treatments on relativity. This might be demonstrated using a high-voltage electron microscope (akin to those at local universities/hospitals) to capture diffraction patterns at two voltages and mapping out changes to the K vs p (p=h/lamda) dispersion relation as the kinetic energy shifts from a quadratic towards a linear dependence on momentum at higher voltages (150-300 kV range). We explore the possibilities of utilizing such an experiment as justification for connecting space and time into a consistent conceptual framework and report back on what your students might discover as a result. Additionally, an adjustment to the experiment may allow one to calibrate the wavelength-change using geometry alone.

BE05: 3:20-3:30 p.m. Particle Physics: An Engaging Part of the High School Program

Contributed – Carol L. Polen, 2004 Stoneheather Rd., Richmond, VA 23238; clpolen@gmail.com

Particle physicists are literally rewriting what we know about the physical world; yet, the typical high school physics curriculum spends little to no time on particle physics. The purpose of the study was to determine whether the inclusion of the particle physics topic in the curriculum increased the engagement and knowledge of high school physics students. A three block unit of instruction was delivered to 122 students in general and Advanced Physics classes. A mixed methods data collection plan was used to gather interest and achievement data with a specific focus on student perspectives and impacts. The particle physics unit increased the enjoyment of physics for 26% of the students, and 73% of the students believed that the unit was a valuable addition to the curriculum. The particle physics unit revealed several important impact points that can be leveraged to increase engagement and achievement in the physics classroom.

Session BF: PER in the Upper Division I

Location: SSU - Atrium
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Mary Bridget Kustusch

BF01: 1:30-2 p.m. Development and Validation of Quantum Mechanics Concept Assessment (QMCA)

Invited – Homeyra R. Sadaghiani, California Polytechnique University, Pomona, 3801 West Temple Ave., Pomona, CA 91768-2557; hrsadaghiani@cpp.edu

As part of an ongoing investigation of students' learning of quantum mechanics, we have developed a 31-item multiple-choice Quantum Mechanics Concept Assessment (QMCA) instrument for first-semester upper-division quantum mechanics. The QMCA could be used for both instructional and research purposes to measure the effectiveness of different curricula or teaching strategies at improving students' conceptual understanding of quantum mechanics. This tool could also help instructors to identify common student difficulties. In this talk, I will discuss the construction process including the use of student interviews and expert feedback for developing effective distractors. Using data from over 10 different institutions, I will also briefly discuss the results of common statistical tests of reliability and validity, which suggest the instrument is presently in a stable, usable, and promising form.

BF02: 2-2:30 p.m. Using and Coordinating Multiple Representations of a Quantum System

Invited – Elizabeth Gire, University of Memphis, 421 Manning Hall, Memphis, TN 38152; egire@memphis.edu

Edward Price, CSU San Marcos

In quantum mechanics, we have a rich set of notational systems for representing quantum systems and making calculations. From a distributed cognition perspective, a student and the external representations generated by the student can be thought of as a cognitive system in which the student and the representations interact. The various features of different quantum notations influence this interaction. I will discuss examples of advanced physics students using and coordinating representations of a quantum system using different algebraic notations - wavefunction, matrix and Dirac notations. I will describe four structural features of these quantum notations and discuss how these features interact with student reasoning.

BF03: 2:30-3 p.m. Conceptual Blending with Complex Numbers in Upper-division Physics

Invited – Hunter G. Close, Texas State University, 601 University Dr., San Marcos, TX 78666-4615; hgclose@txstate.edu

We expect our upper-division students to move flexibly between multiple interpretations and representations of mathematics while doing physics. In conceptual blending theory, the human mind fuses two mental spaces into a blend; in this blend, various vital relations compress to allow the mind to achieve new insight. A fundamental vital relation is "identity," through which two cognitive elements become linked. Eigenvalue problems in quantum mechanics invoke identity when we conceive of an operator as transforming a state into an another that is "the same, except for" a scalar factor. The 2-d rotation matrix and its eigenvalue problem offer an interesting arena for investigating the identity relation in student thinking. This talk reports on an observational study using teaching experiments to understand how students manage the identity relation, including their ability to flexibly reassign the identity relation, and whether this ability is associated with any other measures of success.

BF04: 3-3:10 p.m. Student Difficulties with Boundary Conditions in Electrodynamics

Contributed – Qing X. Ryan, University of Colorado Boulder, 390 UCB Boulder, CO 80309; qing.ryan@colorado.edu

Steven J. Pollock, Bethany Wilcox, University of Colorado Boulder

"Boundary conditions" are an important physics topic that physics undergraduates are expected to understand and apply in many different contexts. In this talk we will present student difficulties using boundary conditions in electrodynamics, primarily in the context of electromagnetic waves. Our data sources include traditional exam questions and think-aloud student interviews. The analysis was guided by an analytical framework (ACER) that characterizes how students activate, construct, execute, and reflect on boundary conditions. Solving these problems also requires using complex notation. While this mathematical tool could be independently analyzed with ACER, we decided to blend and merge the analyses of complex notation with boundary conditions. Thus we are pushing the boundaries of situations where ACER can be applied and we will discuss the benefits and limitations of this framework.

BF05: 3:10-3:20 p.m. Students' Explanations of the Dirac Delta Function During Group Problem-Solving

Contributed – Leanne Doughty, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824-1046, ldoughty@msu.edu

Marcos D. Caballero, Michigan State University

Upper-division physics courses require the use of sophisticated mathematics. In introductory physics, studies have shown that students often lack conceptual understanding of calculus concepts and struggle to implement calculus tools. Research into students' understanding and use of mathematics in upper-level courses is in its early stages. To further this research, we have observed students engaged in group problem-solving during weekly recitation sessions for an upper-division electricity and magnetism course. Early in the course, one task required students to use a Dirac delta function (DDF) to write an expression for the charge density on the surface of a charged hollow cylinder. We report on two group discussions where different students gave a variety of explanations about the purpose of a DDF in this context. By examining these explanations, we can determine the types of understanding students' have about DDFs and which are most productive for their use in physics contexts.

BF06: 3:20-3:30 p.m. Conceptual vs. Mathematical Representations of Plane Waves in Optics

Contributed – Andrew J. Berger, University of Rochester, 405 Goergen Hall / The Institute of Optics, Rochester, NY 14627; ajberger@optics.rochester.edu*

A robust grasp of plane waves is helpful for studying advanced optics topics such as reflection, interference, and the wavelength dependence of refractive index. Although there have been many studies of students' understanding of waves, little work has been dedicated to plane waves, which are particularly challenging both conceptually and mathematically. In this study, 30-45 minute interviews about plane waves were conducted with nine upper-level science/engineering majors, all of whom had previously taken courses in electromagnetic theory where plane waves were used. The interviews revealed several aspects of how students struggle to move between conceptual and mathematical representations of plane waves. Examples include a disconnect between 1-D and 3-D waves (relating to 1-D physically but 3-D only mathematically) and the challenge of representing a 3-D, time-varying vector field in a diagram. Emergent design analysis of the interviews will be presented.

*Sponsored by Scott Franklin.

Session BG: PER: Informing Physics Instruction

Location: John S. Toll Physics Building (PHY) - 1412
Sponsor: AAPT
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Amy Robertson

BG01: 1:30-1:40 p.m. Evaluating SDL and SRL Skills in PBL-based Physics Courses

Contributed – Gintaras Duda, Creighton University, 2500 California Plaza, Omaha, NE 68178; gkduda@creighton.edu

The problem/project-based learning (PBL) literature makes the claim that the use of PBL pedagogy in the classroom helps students develop and grow their self-directed learning (SDL) and self-regulated learning skills (SRL). This talk will detail the creation/adaptation of a Likert-scale survey instrument to measure SDL and SRL skills in a wide-variety of physics courses. Preliminary data will be presented that suggests that PBL methodologies in physics do in fact spur growth in these areas. Further evidence gathered from student reflections will be presented that support and validate this claim.

BG02: 1:40-1:50 p.m. Getting Physics Students to Effectively Read Texts Through Elaborative Interrogation

Contributed – Robert C. Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901-1281; robert.zisk@gse.rutgers.edu

Eugenia Etkina, Rutgers University

Throughout the past three years, Elaborative Interrogation, which has students read a passage from the text and respond to the prompt "Why is this true?" for a sentence from the passage, has been employed in an introductory algebra-based physics course at a large Northeastern university. Students in the course were asked to complete elaborative interrogation questions based on assigned readings as part of their homework each week. In this talk we will present data collected during this intervention that show a relation between student performance and improvement on the elaborative interrogation questions and their course exam scores. We will also discuss data from cognitive interviews conducted as students were responding to the interrogation questions that provide insights into what the students are doing as they are reading the text and answering the questions.

BG03: 1:50-2 p.m. Student Learning Gains from Scientific Induction Labs, Discussions, and Readings

Contributed – Emily Knapp, University of Colorado Boulder, School of Education, 249 UCB Boulder, CO 80309-0249knapp_emily@svvsd.org

Mary Beth Cheversia, Jared Sommervold, Shelly Belleau, Valerie Otero, University of Colorado Boulder

Our research team, composed of four high school physics teachers and two pre-service teachers, believe scientific induction is valuable and critical to student learning. We are exploring at what point in the learning cycle students gain ideas that align with those of the scientific community, i.e. scientific principles. Eight high school physics teachers piloting the Physics and Everyday Thinking (PET) curriculum collected data about student ideas using short diagnostic assessments. These were administered at three points during the learning cycle: before students shared initial predictions, after students conducted laboratory activities, and after students engaged in whole class discussions and readings about the scientific principles. We will present initial findings about student learning gains during induction-type activities. Further analysis will help us capitalize on students' content understanding gains during the PET learning cycle and allow us to tailor future lessons so our instructional moves leverage that portion of the lesson.

BG04: 2-2:10 p.m. Identifying Learning Patterns in Students that Used Two Active Learning Methodologies for the Learning of Basic Electric Circuits' Concepts in High School Students

Contributed – Daniel Sanchez-Guzman, Calz. Legaria, NO. 694, COL. Irrigacion, Miguel Hidalgo, Mexico City, 11500 MEXICO; dsanchezgzm@gmail.com

Ricardo García-Salcedo, Instituto Politecnico Nacional

Educational Data Mining (EDM) is the process of finding learning patterns and to predict some results that can materialize in the learning procedure. These data can be engendered from students through evaluation tests, virtual or physical activities, and homework corresponding to most of the activities that students have to make out with their respective instructional design. In the present work we show the effects of applying EDM algorithms from the results obtaining of two active-learning experiments designed ad-hoc for the learning of Basic Electric Circuits' Concepts in High School students. We examined the effects of using simulations as one active-learning methodology and the use of low-cost experiments in the classroom as the second active-learning methodology this let us to compare the effects of the learning sequences in each methodology and with the results we can re-design the learning sequence and adapting the best exercises of each instructional design.

BG05: 2:10-2:20 p.m. Improving Physics Essential Skills Through Brief, Spaced, Online Practice

Contributed – Andrew F. Heckler, Ohio State University, 191 W Woodruff Ave., Columbus, OH 43210; heckler.6@osu.edu

Brendon D. Mikula, Ohio State University

We developed and implemented a set of online "essential skills" tasks to help students achieve and retain a core level of mastery and fluency in basic skills necessary for their coursework. The task design is based on our research on student understanding and difficulties as well as three well-established cognitive principles: 1) spaced practice, to promote retention, 2) interleaved practice, to promote the ability to recognize when the learned skill is needed, and 3) mastery practice mastery practice, to promote a base level of performance. We report on training on a variety of skills with vector math. Students spent a relatively small amount of time, 10-20 minutes in practice each week, answering relevant questions online until a mastery level was achieved. Results indicate significant and often dramatic gains, with retention at least several weeks after the final practice session, including for less-prepared students.

BG06: 2:20-2:30 p.m. Assessing the Efficacy of an Online Tool for Problem Solving*

Contributed – Evan Frodermann, University of Minnesota-Twin Cities, 116 Church St. SE, Minneapolis, MN 55455-0213; frodermann@physics.umn.edu

Ken Heller, Jie Yang, Leon Hsu, University of Minnesota - Twin Cities

Bijaya Aryal, University of Minnesota - Rochester

Assessing a complex cognitive skill such as problem-solving in an authentic environment such as an introductory physics classes is a challenging task, given the difficulty of measuring students' problem-solving skills, constructing appropriate comparison groups, and managing the many factors that may block or mask such skills in student performance. This talk describes our progress in analyzing a large-scale study at the University of Minnesota to measure the educational impact of computer coaches designed to improve students' problem-solving skills.

*This work was partially supported by NSF DUE-0715615 and DUE-1226197.

BG07: 2:30-2:40 p.m. Practice with Feedback: Comparing Multiple Choice and Natural Language Formats

Contributed – Ryan C. Badeau, The Ohio State University, 191 West Woodruff Ave., Columbus, OH 43210-1168; ryan.badeau@gmail.com

Andrew F. Heckler, The Ohio State University

Force, velocity, and acceleration represent an interesting set of physics concepts in that they are foundational and a persistent source of student difficulty even after instruction. In order to evaluate the effectiveness of different question formats combined with immediate feedback in training on this set of concepts, we have compared computer-based practice with natural language and multiple choice question formats for two different populations of introductory physics students. In addition to comparisons of student progress through the training, student performance is analyzed based on their responses to a previously validated force and motion assessment. Results from an introductory physics course (first semester mechanics) suggest that natural language format questions may provide advantages over their multiple choice counterparts. However, subsequent results in a different introductory physics course (second semester electromagnetism) show that this finding may only be true for less-prepared students and that further replication is necessary.

BG08: 2:40-2:50 p.m. Clinical Comparison of Mastery Style Versus Immediate Feedback Online Activities

Contributed – Noah Schroeder, University of Illinois-Urbana Champaign,1110 W Green St., Urbana, IL 61801; noschroeder@gmail.com

Gary Gladding, Brianne Gutmann, Timothy Stelzer, University of Illinois-Urbana Champaign

Mastery style activities that included narrated animated solutions for instructional support were compared with immediate feedback activities similar to most online homework. In a clinical study, the mastery group attempted question sets in four levels, with animated solutions between each attempt, until mastery was achieved on each level. This combined elements of formative assessment, the worked example effect, and mastery learning. The homework group attempted questions with immediate feedback and unlimited tries. The two groups took a similar amount of time to complete the activity. The mastery group significantly outperformed the homework group on a free response post-test that required students to show their work in solving near and far transfer problems.

BG09: 2:50-3 p.m. Implementation of Online Mastery-style Homework in a Large Introductory Class

Contributed – Brianne N. Gutmann, University of Illinois-Urbana Champaign, 307 W Elm St., #2 Urbana, IL 61801; bgutman2@illinois.edu

Gary Gladding, Timothy Stelzer. Noah Schroeder, University of Illinois-Urbana Champaign

In our preparatory kinematics and dynamics course of about 500 students, we replaced traditional immediate feedback homework with mastery-style homework. This mastery mode required students to perfect a set of questions before moving on to the next level of increased difficulty, and implemented narrated animated solutions to provide instructional support, if necessary. Results, including class performance compared to previous years' students and student behaviors, will be discussed.

BG10: 3-3:10 p.m. MBL-based Online Instruction as an Introductory Tool

Contributed – Katherine Ansell, University of Illinois-Urbana-Champaign, 1110 W Green St., Urbana, IL 61801; crimmin1@illinois.edu

Mats Selen, University of Illinois-Urbana-Champaign

Microcomputer-based laboratory (MBL) formats in non-traditional settings allow us to vary the timing of laboratory-type experiences within the course design. We have used a clinical study to investigate the role of MBL experiences, using the IOLab system, as a tool to introduce new physics topics to students. In the study, college students with little to no physics background were given both passive and active online MBL instruction in varying order. We will discuss the effects of the format and order of instruction on student conceptual learning and retention, as well as the implications of these results for future course design.

BG11: 3:10-3:20 p.m. Student-generated Content: PeerWise Use in Undergraduate Physics Classrooms

Contributed – Alison E. Kay, University of Edinburgh, James Clerk Maxwell Building, Peter Guthrie Tait Rd., Edinburgh, EH9 3FD United Kingdom; a.e.kay@sms.ed.ac.uk

Judy Hardy, University of Edinburgh

In recent years a number of online platforms have been developed to facilitate the creation of student-generated course content. One widely used system is PeerWise, which provides a space where students can create and share multiple-choice questions; answer and rate other students' questions; and engage in discussion with their peers. These types of activities have long been recognized as being effective in increasing students' engagement and enhancing the development of knowledge and understanding, critical thinking, and problem solving skills. As part of a wider study across courses in physics, chemistry, and biology, we present findings from a multi-year study of PeerWise use in early-years undergraduate physics courses. In the majority of courses there is a positive relationship between engaging with PeerWise and end of course exam performance, even when taking into account other influences on performance, such as students' prior ability.

BG12: 3:20-3:30 p.m. Connection Between Participation in Interactive Learning Environment and Teamwork Learning

Contributed – Binod Nainabasti, Florida International University, 11200 SW 8th St., CP 204, Miami, FL 33199; bnain001@fiu.edu

David T. Brookes, Yuhfen Lin, Florida International University

Yuehai Yang, California State University, Chico

Research has shown that an Interactive-Learning-Environment (ILE) can be an effective learning environment for acquiring transferrable knowledge. Our research analyzed characteristics of students' participation in an ILE and their teamwork learning ability, in different areas of two consecutive interactive learning physics classes that implemented the Investigative-Science-Learning-Environment (ISLE) curriculum—a type of widely used ILE. We quantified students' participation in two broad areas: in-class learning activities and class review sessions. To analyze teamwork learning ability, we gave students six problems to be solved in groups (group exams), using physics they had not yet learned. We then gave them six standard physics problems related to the group exams to solve individually. Our results show that the frequency with which students participate in "on topic" physics discussions while engaged in learning activities is only weakly associated with learning, but being off-topic and disengaged has a consistently significant negative relationship with learning and transfer.

Session BH: PER Using MOOCs (Panel)

Location: John S. Toll Physics Building (PHY) - 1410
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Saif Rayyan

MOOCs offer an exciting venue for research. Large numbers and wide diversity of students, together with time-stamped logs of all interactions including those with the instructional resources and the discussion forum, give information not available in on-campus classes. This allows studies of students' behavior, social dynamics, and even permits experimental group-control group experiments. New pedagogies, new types of interactive problems, new standard instruments, and the habits of students who learn the most are all currently being studied. Latest results from this active field will be presented and discussed by a panel with ample opportunity for audience questions and comments.

BH01: 1:30-3:30 p.m. Running AB Experiments in MOOCs: Progress, Results, and Lessons Learned

Panel – Zhongzhou Chen, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139-4307; zchen22@mit.edu

Christopher Chudzicki, Youn-Jeng Choi, David E. Pritchard, Massachusetts Institute of Technology

Qian Zhou, Qinghua University

In summer 2014, the RELATE group at MIT conducted seven different types of experimental vs control group experiments in our online MOOC. Compared to traditional experiments, MOOC experiments are superior in that they offer much larger sample sizes, detailed time-stamped interaction logs, and massive data on students' background ability. However, such superiority also comes at the expense of greater background noise from a less controlled environment. I will talk about the types of experiment designs that are most suitable for an online environment, the kinds of data analysis technique that minimizes random background noise, and the best time-window to run experiments in a MOOC. Findings so far include: 1) doing the same problem on pre-test does not seem to directly improve performance on the post-test, 2) providing a diagram with a problem statement influences students' problem solving behavior and in different cases may change the probability of answering correctly in different directions. I will also introduce other results involving deliberate practice and different styles of instructional video.

BH02: 1:30-3:30 p.m. Student Engagement with Video Course Content in Introductory Mechanics

Panel – Michael F. Schatz, Georgia Institute of Technology, School of Physics, Atlanta, GA 30332-0430, mike.schatz@physics.gatech.edu

John M. Aiken, Scott S. Douglas, Georgia Institute of Technology

Shih-Yin Lin, National Changhua University of Education

Daniel Seaton, Davidson College

When course content is presented on streaming video, data on student interactions with video (clickstream data) provide new insight into student learning behaviors. We describe the analysis of clickstream data from 78 videos delivered in a flipped/blended introductory mechanics course at Georgia Tech. The time evolution of student interactions with course videos depends strongly on the nature of the video content. In particular, student usage of videos with lecture content decreases markedly as the semester progresses; however, student usage of videos with lab content is persistently high throughout the semester, almost independent of the length of the videos. We interpret these results to suggest that student perceptions of the utility of video course content strongly influences student viewing behaviors.

BH03: 1:30-3:30 p.m. MOOC vs. a Standard Physics Class: Demographics and Outcomes

Panel – Michael Dubson, Department of Physics, U. Colorado at Boulder, UCB 390, Boulder, CO 80309-0390; michael.dubson@colorado.edu

Noah Finkelstein, Ed Johnsen, University Colorado at Boulder

David Lieberman, CUNY/Queensborough Community College

In the fall of 2013 and again in spring of 2014, we taught a MOOC version of the calculus-based introductory physics course at the University of Colorado at Boulder (CU). This online course was designed to be as similar as possible to the brick-and-mortar version of the course taught at CU. MOOC students received the same lectures, homework assignments, and timed exams as the tuition-paying CU students. We present data on participation rates and exam performance for the two groups. About 2% of starting MOOC students completed the course. Compared to CU freshmen, the MOOC completers were older, better-educated, and already had a good understanding of Newtonian mechanics. MOOC students who resembled CU freshmen were very unlikely to complete the course.

BH04: 1:30-3:30 p.m. Student Production and Peer Evaluation of Video Lab Reports in an Introductory Mechanics Course

Panel – Scott S. Douglas, Georgia Institute of Technology, 1655 Homestead Ave. NE, Atlanta, GA 37212; scott.s.douglas@gatech.edu

John M. Aiken, Edwin F. Greco, Michael F. Schatz, Georgia Institute of Technology

Shih-Yin Lin, National Changhua University of Education, Taiwan

MOOCs present educators with the opportunity of unprecedented access to large amounts of fine-grained student data, but they pose a challenge to educators wishing to apply the research-based instructional methods known to work best in brick-and-mortar classrooms, including inquiry-based learning and peer interaction. In 2013, the Georgia Institute of Technology began offering an introductory mechanics MOOC run in parallel with an on-campus blended/flipped course, both including hands-on laboratory activities designed to be completed without the need for a dedicated lab space. Peer interaction was introduced to both offerings by means of student-produced, anonymously peer-reviewed video lab reports. This talk will describe peer evaluation in the context of a large-enrollment course and as a method for including peer interaction in an online-only setting.

Session BI: Preparing to Teach Physics to the Next Generation

Location: Glen L. Martin Hall (EGR) - 1202
Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on Physics in Pre-High School Education
Date: Monday, July 27
Time: 1:30–3:30 p.m.

Presider: Bradford Hill

BI01: 1:30-2 p.m. The Patterns Approach for Teaching Physics to the Next Generation

Invited – Heather Hotchkiss, Fairfax County Public Schools, Lee HS, 4201 31st St., S Apt 321, Arlington, VA 22206; heatherjeanhotchkiss@gmail.com

The Patterns Approach for Physics is driven by the recurring question: "How do we find and use patterns in nature to predict the future and understand the past?" Students continually engage in Next Generation Science Standard (NGSS) practices, starting with anchoring experiments that contextualize four common patterns in physics: linear, quadratic, inverse, and inverse square. These anchoring patterns are the tools that help students make meaning from new physics concepts through inquiry. Students are asked to compare low- to high-evidence predictions, collaboratively build models based on data, assess the quality/limitations of their models, and develop proportional reasoning skills. This talk will demonstrate how the Patterns Approach has been applied to freshman through IB physics courses. The Patterns Approach for Physics was published in *The Science Teacher,* March 2013.

BI02: 2-2:30 p.m. Mathematics and Computational Thinking in the Patterns Approach to Physics

Invited – Allison Stafford, Sequoia High School, 103 Crescent Ave. #2, San Francisco, CA 94110; allison.stafford@kstf.org

The Patterns Approach for Physics centers on using patterns in nature to predict the future and understand the past. Join us to explore ways in which I use the Patterns Approach to help my students relate to math as a tool that gives them the power to understand the world around them. The year starts with the four common patterns in physics. Continuing throughout the year, students build on this foundation by applying mathematics and computational thinking to experimental results as well as teacher generated or real-world data sets throughout the physics curriculum. Students model individual or class sets of data, use proportional reasoning skills, and develop basic Excel skills as tools for mathematical thinking.

BI03: 2:30-3 p.m. Tricky Science: Student Research with NGSS and the Patterns Approach

Invited – Jessica M. Scheimer, Knowles Science Teaching Foundation, 956 Q St., Sacramento, CA 95811; jmscheimer@gmail.com

Mike Town, Knowles Science Teaching Foundation

We present a unit that gives students the opportunity to authentically use the inquiry and investigative skills you are likely already teaching to answer their questions about the physical/chemical/biological world. Tricky Science is a scalable, student-centered research project that mimics many aspects of professional research, allowing students to pursue their own research. Students create models to answer their question through the lens of the Patterns Approach (Hill 2013): "How do we find and use patterns in nature to predict the future and understand the past?" This project satisfies many NGSS and Common Core Literacy and Math Standards. Participants will have access to curriculum, information, and opportunity for implementation in their contexts during this session. This project is facilitated by the Knowles Science Teaching Foundation.

BI04: 3-3:30 p.m. The Patterns Approach to Physics, Engineering, and the NGSS

Invited – Jordan Pasqualin, Jones College Prep, 700 S State St., Chicago, IL 60605; jpasqualin@gmail.com

Scott Murphy, St. Joseph's Preparatory School

Do you want to engage and motivate students in authentic and practical ways? The power of engineering lies in the ability to embed scientific thinking within real-world problems, while The Patterns Approach gives students powerful tools to analyze data so they can make quantitative evidence-based decisions. Using The Patterns Approach to model and optimize engineered systems embeds practices that engage students in the authentic pursuit of science. Knowles Science Teaching Foundation Senior Fellows discuss applying the engineering design process in the classroom and share vetted strategies, sample projects, and rubrics. We will also address some of the common roadblocks preventing teachers from engaging students in engineering projects and ideas for overcoming these obstacles. Join us and enhance your existing physics curriculum with content-relevant engineering practices.

Session BJ: Teaching Physics in an IB School

Location: SSU - Benjamin Banneker A
Sponsor: Committee on International Physics Educations
Co-Sponsor: Committee on Physics in High Schools
Date: Monday, July 27
Time: 2–3:40 p.m.

Presider: Tiberiu Dragoiu Luca

BJ01: 2-2:30 p.m. IBDP Physics: An Overview

Invited – Horatiu Pop, International School of Hamburg, Hemmingstedter Weg, 130 Hamburg, 22609; Germany hpop@ishamburg.org*

IBDP Physics course is part of the International Baccalaureate Organisation's Diploma Programme, a rigorous pre-university curriculum designed for students in the 16 to 19 age range. This session aims to provide an overview of the course and highlight its strengths and challenges from the perspective of a practicing teacher who has taught the program for 14 years in a couple of international schools. The following key areas are covered: the physics course in the context of the Diploma Programme, a general presentation of its components (internal and external assessment, practical work, Group 4 project, etc.), the syllabus content and its latest revision (2016+), approaches to teaching and learning and available resources (textbooks, Online Curriculum Centre, etc.).

*Sponsored by Tiberiu Dragoiu Luca

BJ02: 2:30-3 p.m. IBDP Physics: A Complement to Advanced Placement

Invited – Drew C. Kesler, Newark Academy, 91 South Orange Ave., Livingston, NJ 07039; dkesler@newarka.edu

IB Diploma Program Physics is a lab-driven course with an exhaustive scope of topics. It provides an excellent alternative to Advanced Placement and is attractive to students who are unsure about their college plans. This session provides notes from the experience of a teacher who currently teaches both AP C and IBDP Physics in an IBDP school in NJ. It compares the two programs, details how each are implemented, and shows that IBDP Physics can be a valuable method of strengthening the physics offerings at any school. In addition, this session provides notes from the experiences of college guidance counselors as they manage IBDP students headed for both liberal arts colleges and engineering universities.

*Sponsored by Tiberiu Dagoiu-Luca

BJ03: 3-3:30 p.m. IBDP Physics: Labwork and Modeling

Invited – Daniel Doucette, International School of Latvia, Meistaru iela 2 Pinki, Babites pag. LV-2107, Latvia; danny.doucette@gmail.com

This session aims to present information that will be useful to teachers and others interested in International Baccalaureate Diploma Programme [IBDP] physics. A difficult component of the IB physics program is the development of a suitable scheme of practical work. The current syllabus encourages integrated labwork as a form of instruction, and projects as a form of individualized assessment. First, I will introduce the "required practicals" and suggest ways to conduct these mandatory labs. Second, I will present the (new) internal assessment and outline ways to manage this challenging assessment activity. Third, I will discuss the other IBDP projects that related to physics: the extended essay and the Group 4 project. Finally, I will seek to answer the question of how the popular Modeling approach can be used to teach IBDP physics.

Session BK: The Art and Science of Teaching

Location: SSU - Benjamin Banneker B
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 27
Time: 2–3:30 p.m.

Presider: Andy Gavrin

BK01: 2-2:30 p.m. Art as a Science-Communication Tool

Invited – S. James Gates, University of Maryland-College Park, Physics Department, Room 4125, College Park, MD 20742; gatess@umd.edu

In presenting complicated concepts to the public, the presenter has since the middle 1990s observed the effectiveness of utilizing graphical representations to replace solely narrative ones. The great bulk of the intellectual content in his popular-level presentation "Superstring Theory: The DNA of Reality" was designed with this principle as a foundation. More surprisingly the use of graphical representations in his collaboration with mathematicians was the key for establishing a deep and robust discussion about his research in supersymmetry that led to the unusual discovery of error-correcting codes playing an unsuspected role in superstring theory. Aspects of lessons learned in these disparate realms will be presented.

BK02: 2:30-3 p.m. Research-validated Approach(es) to Transforming Upper-division Courses

Invited – Steven Pollock, CU Boulder, 390 UCB, Department of Physics, Boulder, CO 80309; steven.pollock@colorado.edu

At most universities, upper-division physics courses are taught using a traditional lecture approach that doesn't make use of research-based instructional techniques and curricular reforms found to improve student learning at the introductory level. Why is that? Have we already "optimized" our courses, or might pedagogical changes be valuable? Guided by observations, interviews (students and faculty) and analysis of student work, we are transforming some upper-division courses using principles of active engagement and learning theory. We are sensitive to the unique aspects of both upper division students and faculty. I will outline some of these reform efforts, including consensus learning goals, conceptual questions, tutorials and modified homework. These examples show what transformed upper-division courses can look like, and offer insights into student difficulties in advanced undergraduate topics. We examine the effectiveness and impacts of these reforms, and the complex questions of sustainability and adaptation essential to supporting meaningful change.

BK03: 3-3:30 p.m. Teaching Physics Standing on Your Head

Invited – Edward F. Redish, University of Maryland, Department of Physics, College Park, MD 20742-4111; redish@umd.edu

Professional physicists quickly learn the power and value of mathematical representations, not only as calculational tools, but as ways to organize conceptual knowledge and reason about physical situations. Often, this is because we started out with enjoyment and success in math and were enthralled by the idea that this beautiful stuff could actually be used to describe the world. Many of our students (especially those in service courses) don't come to physics with this orientation about math. An analysis of epistemological resources and stances chosen by physics faculty and students suggests that including math in our classes in the way most comfortable and natural to us as physicists might not help our students learn to use math in science. A more productive approach might be to run the math "upside down" by first building a strong physical intuition and only then helping students translate to rigorous math.

Session BL: What's Working in Other Disciplines: Recruitment and Retention

Location: SSU - Charles Carroll B
Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on Space Science and Astronomy
Date: Monday, July 27
Time: 2–3:30 p.m.

Presider: Jill Marshall

BL01: 2-2:30 p.m. Lessons from Astronomy: Breaking Down Barriers and Creating Inclusive Climates

Invited – Kimberly Coble, Department of Chemistry and Physics, Chicago State University, Chicago, IL 60628-1598; kcoble@csu.edu

Though physics and astronomy are similar disciplines, the proportion of women in astronomy has risen faster than the proportion of women in physics, which has plateaued in recent years. I will describe strategies that have been successful in astronomy as well as new efforts to address intersectionality. Racism, sexism, heterosexism, and other forms of discrimination are linked and we must move beyond a one-dimensional approach toward equity and inclusion. I will report on research highlights, tools, and strategies from the Inclusive Astronomy 2015 conference, which is organized around breaking down barriers to access for marginalized groups, creating inclusive climates, addressing access to power and leadership, and establishing a community of practice.

BL02: 2:30-3 p.m. Women in Chemistry: Catalyzing Change in the Chemical Sciences

Invited – Mary M. Kirchhoff, American Chemical Society, 1155 16th St. NW, Washington, DC 20036; m_kirchhoff@acs.org

Since 2004, the percentage of women and men earning bachelor's degrees in chemistry has roughly been equal, according to data reported by the American Chemical Society Committee on Professional Training. The percentage of women who go on to earn doctoral degrees, however, declines to about 39 percent. A recent survey of graduate students in the chemical sciences suggests that women may not have access to the same opportunities to advance professionally while in graduate school as do men. This presentation will highlight trends in the advancement of women in chemistry and focus on efforts to recruit and retain them in academia and the chemical industry.

BL03: 3-3:30 p.m. Using Socio-Cultural Factors to Broaden Participation and Advancement in STEM

Invited – Frances D. Carter-Johnson, 6701 Rockledge Dr., Room 2040N, MSC 7808, Bethesda, MD 20892; fdecarter@gmail.com

Female underrepresentation in science, technology, engineering and mathematics (STEM) is a persistent problem often exacerbated for specific groups of women of color, such as underrepresented minority women in physics at all educational and leadership levels. Their limited representation results in a dearth in the groups' perspectives in the STEM community that restricts their contributions to transformational change. This paper will discuss challenges and problems with current precedent-based solutions applied at various educational and leadership levels. We will then discuss alternatives that focus on socio-cultural and culturally relevant factors aimed at producing solutions that better match to needs of women of color in STEM. As demographics in the U.S. rapidly change, these and other alternative approaches are critical to improving attitudes, environments and outcomes for both leaders and participants in STEM.

Session CA: K-12 PER I

Location: SSU - Charles Carroll A
Sponsor: Committee on Physics in High Schools
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 27
Time: 4–5:50 p.m.

Presider: Dan Crowel

CA01: 4-4:30 p.m. Investigating STEM Beliefs and Practices of Physical Science Teachers

Invited – Emily A. Dare, University of Minnesota, 320 LES, 1954 Buford Ave., St. Paul, MN 55108; dare0010@umn.edu

Joshua A. Ellis, Gillian H. Roehrig, University of Minnesota

Recent national documents call for improvements in K-12 STEM education to increase STEM literacy and motivate students to pursue STEM fields (National Research Council, 2013). However, there is a lack of opportunities for teachers to participate in integrated STEM-related professional development and develop their own STEM-integrated practices. Further, there is little research devoted to understanding teacher perceptions of the nature of STEM integration. By examining classroom practices and understanding teachers' experiences, we can learn how to prepare these teachers to bring scientific and engineering practices to their classrooms. This presentation focuses on two studies that examine the integration of STEM in middle and high school physical science classes, where the four disciplines represented by STEM frequently intersect. Through analyzing data from both observer and participant perspectives, our work aims to better understand the successes and challenges that science teachers face as they work to bring integrated STEM to their classrooms.

CA02: 4:30-5 p.m. Contributing to Meaning Making: Facilitating Science Discourse

Invited – Scot Hovan, St. Paul Academy and Summit School, 1712 Randolph Ave., St. Paul, MN 55105; shovan@spa.edu

The Next Generation Science Standards (NGSS) identify eight practices as essential to science and engineering, and several of these practices expect students to engage in scientific discourse. Modeling Instruction is one movement in physics education that organizes high school physics content around a small number of student-derived scientific models, and it relies on student discourse for the design, development, and deployment of these models. This presentation shares the findings of a self-study of one high school physics teacher's experience facilitating large group discourse in the high school modeling physics classroom. The analytical framework by Mortimer and Scott (2003) was used to characterize the classroom talk and the discourse facilitation moves that were employed, and elements of discourse analysis were used to examine some of the tensions that were experienced in the facilitation of this discourse.

CA03: 5-5:10 p.m. Consensus Paragraphs to Promote Connections Between Inference and Physics Principles

Contributed – Nicole B. Schrode, University of Colorado-Physics Education Department/Longmont High School, 3363 Madison Ave. V121, Boulder, CO 80303; brown_nicole@svvsd.org

Mike Ross, Valerie Otero, Luke Degregori, Katherine Eason, University of Colorado

Elizabeth Nell, University of Colorado/Silver Creek High School

Adam Francis, University of Colorado/Erie High School

Students often have difficulty integrating what they observe and infer in high school physics class with more formal scientific principles. Our Teacher Research Team is using "consensus paragraphs" in the form of Claim, Evidence, Reasoning (CER) writing assignments to assess how students integrate evidence and inference with more general principles and abstract, conceptual ideas. After each Physics and Everyday Thinking-High School learning cycle (Initial Ideas, Collecting and Interpreting Evidence, Consensus Discussion, Scientists Ideas, and Math concepts) our students write consensus paragraphs in a CER format. We then apply a rubric to assess how well they use each of the CER elements and compared our CER data to data from a more traditional physics class. We will discuss observed differences in students' use of evidence and what type of evidence students use to support scientific claims.

CA04: 5:10-5:20 p.m. Teacher Growth in Pedagogical Knowledge of Energy in the MainePSP

Contributed – Michael Carl Wittmann, University of Maine, 5709 Bennett Hall, Orono, ME 04469-5709; mwittmann@maine.edu

Carolina Alvarado, Laura A. Millay, University of Maine

As part of the Maine Physical Sciences Partnership (NSF #0962805), we have studied middle school teachers' growth in their knowledge of both energy concepts and students' ideas. A subset of the teachers in our partnership have answered multiple survey questions over several years, allowing us to compare their responses over time. We analyze two questions from our survey in terms of both content knowledge (what their answers are) and knowledge of student ideas (what they think the most common incorrect answer will be). We find improvement in all teachers' responses over time. We believe that these improvements are due at least in part to the professional development activities of our project: use of hands-on learning materials with teachers to promote content understanding, engagement in student data from the energy survey, and a culture of community-building and shared professional expertise.

CA05: 5:20-5:30 p.m. Professional Development Promotes Deeper Understanding by Teachers Analyzing Teacher Responses

Contributed – Carolina Alvarado, University of Maine, 5727 Estabrooke Hall, Orono, ME 04469-5727; carolina.alvarado@maine.edu

Michael C. Wittmann, Laura Millay, University of Maine

In the Maine Physical Science Partnership (NSF #0962805) we held a collaborative pedagogical development session where K-12 science teachers analyzed their own responses to open-ended questions regarding a specific energy scenario. Teachers were not aware that the data included two teachers' responses from two consecutive years. The second year teachers' responses showed a refinement in the understanding of energy compared to the first year responses. After analyzing each of the four responses, teachers expressed a stronger preference for the second year responses, consistent with the researchers' observation of growth. At the same time, teachers moved from an evaluative mindset to the recognition of the useful ideas shown in all the teachers' answers, including those which first were evaluated negatively. In addition, during this discussion, teachers created a collective answer that they noted was far richer than what any of them had individually stated before.

CA06: 5:30-5:40 p.m. Professional Development of Physics Teacher Leaders in a Professional Learning Community (PLC)

Contributed – Smadar Levy, Weizmann Institute of Science, 22 Zufit st., Hod Hasharon, Israel 45354; Israel smadarlevy@gmail.com

Bat Sheva Eylon, Esther Bagno, Hana Berger, Weizmann Institute of Science

A physics teaching team at WIS enacts a PLC of physics teacher-leaders leading 10 regional PLCs of high school physics teachers (200 teachers) all over Israel. The PLCs aim to develop student-centered and engaging teaching. Using a "fan model" led by the WIS team, 25 physics teacher-leaders meet every two weeks for four hours throughout the year preparing the consecutive meetings of their PLCs. Prior to these meetings, the teacher-leaders engage as learners in research-based teaching strategies; implement customized-versions in their classes; reflect collaboratively with peers on evidences from their practice; and conceptualize the learning process. These stages act as a model for running their own PLCs and are supported there by insights gained in the previously described process. Research indicates that the teacher-leaders develop a strong sense of community; deepen physics knowledge (CK) and pedagogical content knowledge (PCK); and acquire leading skills. The rational and the model will be elaborated.

CA07: 5:40-5:50 p.m. Modeling Physics in Urban High Poverty High Schools

Contributed – M. Colleen Megowan-Romanowicz, American Modeling Teachers Association, 5808 13th Ave., Sacramento, CA 95820; amtaexec@modelinginstruction.org

We worry about diversity in the physics community, and a number of programs have been developed at the undergraduate and graduate levels to support women and minority students who major in physics. There is less support for these students at the pre-college level. It is left to individual teachers to find ways to connect with students, to ignite their interest and to encourage them to pursue a college degree. Teaching high school physics in an urban high poverty setting entails a number of unique challenges (e.g., attendance, turnover, ELL, resources, school counselor biases, culture) that are not encountered in the suburban middle class schools. I will report on the results of a survey of Modeling physics teachers who work in urban poor schools and illustrate findings with case studies that reveal both the barriers and the affordances they encounter and how teachers navigate them.

Session CB: Adapting the Teacher In Residence (TIR) Role to Local Contexts

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Teacher Preparation
Date: Monday, July 27
Time: 4–4:50 p.m.

Presider: Jon Anderson

CB01: 4-4:30 p.m. TIR at MU: Inspiring Future Teachers Through Physics First

Invited – Kory Kaufman, University of Missouri, 223 Physics, Columbia, MO 65211; kaufmankl@missouri.edu

Karen King, University of Missouri

The University of Missouri's recruitment program for future physics teachers rests on the foundation of a long-standing successful partnership between the MU Department of Physics and Astronomy faculty and Columbia Public Schools (CPS) physics faculty. For almost a decade, CPS ninth-grade teachers have been using the modeling-based MU Physics First program and most have been through an extensive professional development program. Early on, we recognized that the palpable excitement in Columbia Physics First classrooms had the potential to ignite our undergraduate students' interest in teaching. To "hook" potential physics education majors, our Teacher in Residence (TIR) places undergraduates in ninth-grade physics classrooms, where they assist the teacher in facilitating collaborative student learning. The TIR coordinates this Learning Assistant (LA) program, which has proven to be the most successful part of our recruiting program, Tomorrow's Outstanding Physics Teachers (TOP Teachers).

CB02: 4:30-4:40 p.m. Service-Learning Projects for Pre-Service Physics Teachers

Contributed – Kevin H. Thomas, University of Central Florida, 4111 Libra Dr., Physical Sciences Bldg., 430 Orlando, FL 32816; kevin.h.thomas@gmail.com

In our second year as a PhysTEC comprehensive site at the University of Central Florida (UCF), we focused on our increasing number of pre-service teacher mentees. With continuing efforts in improving our Learning Assistant (LA) program, the approval of a new BA in Physics, and our Teaching Introductory Physics (TIP) course, our students have new opportunities to get training and experience with teaching high school physics. As a result of successful implementations of second-semester LAs into local high school classrooms, we added a service-learning component to the TIP course. The service-learning program at UCF allows students to meet the needs of community partners while practicing and reinforcing learning objectives. The UCF Teacher-in-Residence will discuss the application of service-learning in the TIP course and the impact on the physics teachers, their classrooms, and our students. He will also outline other recruiting and professional development efforts begun during the past year.

CB03: 4:40-4:50 p.m. PhysTEC Teacher In Residence at Georgia State University

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

The environment in which the PhysTEC Teacher-In- Residence at Georgia State University operates will be presented, as well as experiences during the 2014-2015 school year. Information about challenges faced and successes will be included.

Session CC: Best Practices in Educational Technology I

Location: Jimenez Hall (JMZ) - 0105
Sponsor: Committee on Educational Technologies
Date: Monday, July 27
Time: 4–6 p.m.

Presider: Larry Engelhardt

CC01: 4-4:30 p.m. Multiple Tries on Trial

Invited – Gerd Kortemeyer, Michigan State University, Lyman Briggs College, East Lansing, MI 48825; kortemey@msu.edu

It is common for online homework systems to allow multiple tries for learners to arrive at the correct solution. The argument for this policy is that it allows mastery-based learning and reduces "cheating" (i.e., blind copying of answers from others). But how do learners really make use of these multiple allowed tries? How well do the desired outcomes of granting multiple tries compete with undesirable side effects, such as guessing and procrastination of much-needed help seeking (e.g., taking advantage of office hours)? Is there an optimum number of allowed tries? The talk presents multiple perspectives on these questions, including analyses of transaction logs and survey data, and it proposes a model for student behavior in these settings.

CC02: 4:30-5 p.m. Integrating Computation (including some HPC) into the Undergraduate Physics Curriculum

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

While computation has entered the undergraduate curriculum in the last two decades in the form of isolated courses on computational and numerical methods, and in a few institutions as a comprehensive program of study, computational instruction in an integrated mode, wherein the need for a computational approach to solving a particular problem is generated as a natural way to reveal the physics of a particular situation, is ostensibly scarce. The integration of computation into undergraduate physics courses adds value to the curriculum by providing a third way to understand and advance physics (adding to analytical theory and laboratory experiments). Furthermore, the importance of exposing STEM students to high performance computing (HPC), especially to the possibilities of harnessing the potential of Graphics Processing Units (GPUs), will only increase. I will suggest ways that computation can be (relatively) unobtrusively integrated into introductory and advanced undergraduate physics courses, and provide some practical examples.

CC03: 5-5:30 p.m. Blended Learning in a Collaborative Classroom

Invited – Stephen Collins, Lusher Charter School, 5624 Freret St., New Orleans, LA 70115; stephen_collins@lusherschool.org

Constructivist approaches to physics education like Modeling stress the importance of student collaboration and have been proven to positively impact student understanding. Computer-based learning, on the other hand, offers the potential of personalized learning paths within the classroom. Many attempts at blended learning suffer from the inability of current commercial software to integrate with classroom activities. In this session, the author presents software that connects the digital learning space with the collaborative activities of the classroom, leveraging the potential of both.

CC04: 5:30-6 p.m. Using Simulations and Interactive Questioning Activities in a 1:1 Classroom

Invited – Tom Henderson, Glenbrook South High School, 1931 South Falcon Dr., Libertyville, IL 60048; physicsclassroom@comcast.net

High School teachers in 1:1 schools that depend on Chromebooks and iPads are faced with the challenge of replacing their previous repertoire of Java/Flash/Shockwave applications with new HTML5 tools. The presenter will demonstrate a variety of tablet-friendly simulations and interactive questioning applications that have served as useful visualization, concept-building, and formative assessment tools and turn the 1:1 device into much more than a classroom decoration.

Session CD: Frontiers in Astronomy

Location: Jimenez Hall (JMZ) - 0220
Sponsor: Committee on Space Science and Astronomy
Date: Monday, July 27
Time: 4–6 p.m.

Presider: Richard Gelderman

CD01: 4-4:30 p.m. Meteorites, Asteroids, and the Origin of Life

Invited – Jason P. Dworkin, NASA Goddard Space Flight Center, Astrochemistry, Code 691, Greenbelt, MD 20771; jason.p.dworkin@nasa.gov

A little over 4.5 billion years ago, our solar system was a disk of gas and dust, newly collapsed from a molecular cloud, surrounding a young and growing protostar. Sometime around 4 billion years ago, life emerged on Earth, and possibly other planets and moons. The chemistry that led to life has largely been consumed by the geology of Earth and the organisms that inhabit it. By studying the leftovers of planet formation can we glimpse at the chemistry and processes available to the ancient Earth. This presentation will focus on some recent analyses organic compounds in carbonaceous chondrite meteorites and the upcoming OSIRIS-REx mission NASA will launch in 2016 to return samples from asteroid Bennu in 2023. More about OSIRIS-REx at http://asteroidmission.org

CD02: 4:30-5 p.m. Simulating the Universe

Invited – Michael Boylan-Kolchin, University of Maryland, Department of Astronomy, College Park, MD 20742-2421; mbk@astro.umd.edu

Our understanding of the Universe and its composition has changed dramatically over the past two decades. We now believe that normal matter, which makes up all components of our daily existence and all objects we see with our telescopes, comprises a mere 5% of the Universe. The remaining 95% is composed of "dark matter" and "dark energy," mysterious substances whose nature is currently the subject of intense study. Nevertheless, astrophysicists have made tremendous strides in understanding the Universe and its evolution. Cosmological simulations have emerged as one of the most powerful tools in this endeavor: they allow us to initialize and evolve "virtual universes" in which we can study galaxy formation and the growth of cosmic structure from shortly after the Big Bang to the present day. I will give an overview of cosmological simulations and discuss recent advances in this exciting field.

CD03: 5-5:30 p.m. The Discovery of High Energy Astrophysical Neutrinos

Invited – Kara Hoffman, University of Maryland, Department of Physics, College Park, MD 20742; kara@umd.edu

In the summer of 2012, the IceCube Neutrino Observatory announced the observation of two neutrino interactions deep in the south polar icecap, each with energies in excess of a quadrillion electron volts, making them the highest energy neutrinos ever observed. Neutrinos are the ideal astrophysical messenger. Chargeless and nearly massless particles, neutrinos escape dense astrophysical objects to travel nearly unimpeded to Earth, potentially carrying with them a host of information about their progenitors. However, the detection of high-energy neutrinos posed a technical challenge that was only recently realized with the construction of IceCube. The first observatory class neutrino detector, IceCube comprises over a cubic kilometer of clear polar ice. Since the 2012 announcement, further analysis and additional data have revealed these first ultra high energy neutrinos to be the tail of a larger spectrum. Where did they come from, and what can they tell us about the most energetic objects in our Universe?

Session CE: Integrating Computational Physics at the Introductory Level

Location: Art-Sociology Building (ASY) - 2203
Sponsor: Committee on Physics in Two-Year Colleges
Co-Sponsor: Committee on Educational Technologies
Date: Monday, July 27
Time: 4–5:40 p.m.

Presider: Thomas O'Kuma

CE01: 4-4:30 p.m. Developing Activities and Using Computational Modeling in University Physics

Invited – Dwain Desbien, Estrella Mountain Community College, 10530 W Angels Lane, Peoria, AZ 85383; dwain.desbien@emcmail.maricopa.edu

This talk will discuss the development of activities for computational modeling as part of the ATE Project for Physics Faculty.* Examples of the activities will be shared and results from using some in University Physics classes at EMCC. These projects utilize both vPython and Excel for computational modeling. Student examples will be shown and further plans on implementing computational modeling will be discussed.

*This project is supported in part by grants (#0603272 and #1003633) from the Division of Undergraduate Education (DUE) through the AdvancedTechnological Education Program (ATE) of the National Science Foundation.

CE02: 4:30-5 p.m. Projects and Practices in Physics – Inquiry-based Computational Modeling

Invited – Marcos Caballero, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824-1046; caballero@pa.msu.edu

Paul W. Irving, Stuart H. Tessmer, Michael Obsniuk, David Stroupe, Michigan State University

Most introductory science courses emphasize the acquisition of conceptual and procedural knowledge, but fail to prepare students to engage in science practice including constructing explanations, developing models, and using computational modeling. We have designed an introductory mechanics course that engages students with computational modeling through the use of short modeling projects. By engaging students in more authentic science work, we aim to help students develop their science identity while they also appropriate the practices and understanding of a scientist. These projects require students to negotiate the meaning of physics concepts in small groups and to develop a shared vision for their group's approach to developing a solution. The projects that the groups are presented with are sufficiently complex such that students make use of and move between analytical and computational techniques. We will present the motivation for and structure of this course, as well as some preliminary learning and affective outcomes.

CE03: 5–5:10 p.m. Learning Computer Programming Through Projects in Science and Engineering

Contributed – Anindya Roy, Johns Hopkins University, Materials Science and Engineering, Baltimore, MD 21218-2680; royanin@gmail.com

Camilo Vieira, Alejandra J. Magana, Purdue University

Michael J. Reese, Michael L. Falk, Johns Hopkins University

Students often learn computer programming outside the discipline where they apply it. Translating this knowledge to solve problems in science and engineering is often a struggle for the learners. We investigate this issue at the beginning-undergraduate level through creating a course at the Materials Science and Engineering department at Johns Hopkins University. "Computation and Programming for Materials Scientists and Engineers (CPMSE)" is in the fourth year of implementation as of spring 2015. Students enrolled in CPMSE watch video lectures at home, and engage in collaborative in-class group activities. They learn programming and engage in week-long MSE projects in alternate weeks. We collected data to track learning outcomes through surveys, think-aloud activities, and detailed course grades. Multi-year implementation of CPMSE suggests positive gain in students' perception of ability, utility, and intent to use programming in disciplinary context. We also learn about the challenges to integrating programming with science projects.

CE04: 5:10–5:20 p.m. The Influence of Analytic Procedures on Students' Computational Modeling Practices

Contributed – Brandon R. Lunk, Elon University, 2625 Campus Box, McMichael Science Building, Elon, NC 27244; blunk@elon.edu

Robert Beichner, Ruth Chabay, North Carolina State University

With the growing push to include computational modeling in the introductory physics classroom, we are faced with the need to better understand students' computational modeling practices. While existing research on programming comprehension explores how novices and experts generate programming algorithms, little of this discusses how students' existing content knowledge and expectations of typical problem-solving approaches influence their interaction with the programming environment. In this talk, we report on a study during which we observed introductory physics students completing computational models of Newtonian gravitation and Rutherford scattering as part of their course laboratory session. While the labs featured computational modeling activities, numerical methods were largely absent from other aspects of the course. We discuss students' heavy reliance on analytic procedures during the activities we observed as well as some resulting instructional implications.

CE05: 5:20-5:30 p.m. Introducing Computation by Integrating It into a Modern Physics Course

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

There is a need to develop materials that introduce students to computational physics with problems that are meaningful and challenging, yet are neither overwhelming to the students nor take substantial time from the more traditional theoretical and experimental components of a course. We have been working on a project to introduce computational physics in the undergraduate curriculum by blending computation and experimentation in the Modern Physics course and laboratory with materials that discuss contemporary physics subjects (statistical mechanics, quantum dots, LASERs, superconductivity, etc). In this talk we will outline the homework problems and laboratories that have been developed as part of this project, discuss our experience implementing them, and give interested faculty information on how to obtain these materials.

CE06: 5:30-5:40 p.m. Teaching Orbital Motion Using Computational Physics: Beyond Circular Orbit

Contributed – Phuc G. Tran, John Tyler Community College, 800 Charter Colony Parkway, Midlothian, VA 23114; Ptran@jtcc.edu

The study of orbital motion in introductory physics is usually limited to circular orbit as solving the relevant differential equation requires mathematical sophistication beyond normal first or second year students. Numerical solution however is straightforward and can be readily grasped by students. The computational requirements are minimal; Students can carry out calculation using EXCEL.

Session CF: Introductory Courses I

Location: Art-Sociology Building (ASY) - 2309
Sponsor: AAPT
Date: Monday, July 27
Time: 4–6 p.m.

Presider: Kathleen Falconer

CF01: 4-4:10 p.m. Modern Physics for General Education Students: Teaching "Claims, Evidence, Reasoning"

Contributed – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099; pawla@uwplatt.edu

One of the most important goals of a general education science course is to teach students what it means to provide quantitative and/or experimentally grounded evidence for a claim and how to explain the reasoning that links the evidence to the claim. The historical development of the three pillars of Modern Physics (kinetic theory, relativity and quantum theory) provides a perfect context for teaching the Claims, Evidence, Reasoning framework of argumentation and at the same time supplies a motivation for introducing students to several core models of classical physics (particles, momentum, kinetic energy, electric energy and waves). In this presentation I describe an experimentally-grounded introduction to Modern Physics for a general education audience that was offered at the University of Wisconsin-Platteville for the first time in spring 2015. Laboratories, reading assignments, homework, and exams all employed the Claims, Evidence, Reasoning framework in varying degrees. Course materials are available upon request.

CF02: 4:10-4:20 p.m. Practical Electronics: A New Course for Non-Science Majors

Contributed – Stephen H. Irons, Yale University, 217 Prospect St., New Haven, CT 06511; stephen.irons@yale.edu

I will report on the implementation of a new course designed to teach basic electronics using an active learning approach to non-science majors. The primary objective was to give students a practical understanding of and skills in analog electronics as well as simple residential electrical design. The Arduino platform was also introduced. Class time consisted of short interactive discussions with the majority of the time given over to hands-on activities that complemented online quizzes and written homework. A student-conceived project, paper, and presentation served as a final exam. Student learning was assessed using the Electrical Circuits Conceptual Evaluation (ECCE) as a pre and post test. I will present these results and other lessons learned.

CF03: 4:20-4:30 p.m. Physics and Engineering Design in a Calculus Class*

Contributed – Jill A. Marshall, University of Texas at Austin, 1 University Station D5705, Austin, TX 78712; marshall@austin.utexas.edu

Hye Sun You, University of Texas

The University of Texas has developed a series of design activities to be implemented in the discussion section meetings of our introductory calculus sequence for engineers, with funding from NSF DUE grant 0831811. These modules include: (1) evaluating a model landscape surface for flooding hazard by calculating gradients and directional derivatives, (2) determining how to maximize the power output to a network of speakers, (3) finding the optimum position, the center of mass, to locate supports for a dam. In each case students used calculus to model the situation, then constructed a physical model to test the mathematical model. An additional online module allowed students to use Taylor Series to predict vibration modes in buildings during earthquakes. I will present results of a pilot implementation with students, including a pre/ post comparison of attitudes of students who did and did not engage in the design activities.

*Supported by NSF DUE 0831811

CF04: 4:30-4:40 p.m. A Transition from Calculus- to Algebra-based Physics

Contributed – Grant D. Thompson, Wingate University, 220 North Camden Rd., Wingate, NC 28174; g.thompson@wingate.edu

James W. Hall, Kenneth S. Kroeger, Wingate University

Calculus-based introductory physics courses have been offered for decades at Wingate University, while due to the lack of resources, the algebra-based curriculum was not offered. However, the physics requirements of new, health-related professional programs at our institution require our modest department to merge algebra-based physics into our curriculum, while still maintaining the calculus-based requirements of other majors. Due to departmental resources, it is not feasible to offer both courses simultaneously to satisfy requirements of various majors. We will be transitioning to a new course offering pathway in the fall of 2015 in which all students enroll in the algebra-based Physics I and have an option to pursue either a similar Physics II course or an enhanced calculus-based Physics II course that revisits Physics I and its calculus applications.

CF05: 4:40-4:50 p.m. New Introductory Physics Major Course Sequence

Contributed – Steven H. Mellema, Gustavus Adolphus College, 800 West College Ave., St Peter, MN 56082; mellema@gustavus.edu

Charles F. Niederriter, Gustavus Adolphus College

Several years ago, in an effort to address multiple concerns about our physics major, we undertook an overhaul of the introductory course sequence in our curriculum. The most significant change was a rearrangement of the sequence of topics taught into four, semester-long, theme-based courses: The Cosmic Universe; The Mechanical Universe; The Electromagnetic Universe; and the Quantum Universe. This involved abandoning the time-worn tradition of teaching classical physics before modern physics, and meant using astronomy to teach physics in the very first semester. This is a report, four years into the new sequence, about the motivations for and the results of the changes.

CF06: 4:50-5 p.m. Incorporating Modern Physics into the First-year Introductory Physics Course Sequence

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

Alice Churukian, Reyco Henning, The University of North Carolina at Chapel Hill

At the University of North Carolina at Chapel Hill, we have incorporated Modern Physics into our first-year introductory physics course sequence required for students of the physical sciences (chemistry, math, computer science, applied science, and physics majors). This change of the curriculum from three semesters into two has been rather challenging for both the instructors and students. To make the course more interactive and improve student learning, the course is taught in a lecture/studio format where students attend two hours of lecture and four hours of studio per week. The large-enrollment lectures incorporate think-pair-share clicker-style questions, and the smaller studio sections use collaborative learning techniques such as hands-on lab activities and group problem solving. We will share insights and lessons learned from our first year implementing this new course sequence.

CF07: 5-5:10 p.m. Adapting CLASP for San José State: Successes and Challenges

Contributed – Annie Chase, San José State University, 1 Washington Sq., San Jose, CA 95192-0001; annie.chase@sjsu.edu

Cassandra Paul, San José State University

For three years, San José State University (SJSU) has been piloting the Collaborative Learning through Active Sense-making in Physics (CLASP) curriculum in our algebra-based, introductory physics course. Originally developed at UC Davis, CLASP is characterized by the use of models and integrated discussion-labs where hands-on, small-group activities promote sense-making and problem-solving skills. Adapting this curriculum for use at SJSU has presented several challenges. In addition to tweaking the instructional materials, we also needed to change the time-structure of the labs and lectures in order to provide a learning environment similar to that of CLASP's intended use. This fall, we are rolling out the course beyond experimental sections, and implementing new changes including: twice-weekly TA meetings and restructuring lecture/lab time frames. In this talk we discuss the changes we made, challenges we faced, and tips for how other institutions may follow our lead.

CF08: 5:10-5:20 p.m. Undergraduate Learning Assistants in Introductory Physics Classes

Contributed – Thomas H. O´Neill, James Madison University, 901 Carrier Dr., Harrisonburg, VA 22807; oneillth@jmu.edu

With the support of PhysTEC, James Madison University has found the use of undergraduate Learning Assistants in a flipped-classroom and tutorial model for the Calculus-based Introductory Physics class results in an approximately 40% gain in pre-/post-test administrations of the Force Concept Inventory (Mechanics portion) and the Survey of Ideas in Electricity and Magnetism (E&M portion). Student satisfaction with the course also improved over traditional lecture methods. The flipped-classroom and tutorial model is being successfully extended to the larger Algebra/Trigonometry Introductory Physics classes.

CF09: 5:20-5:30 p.m. Testing the Waters at Princeton

Contributed – Jason Puchalla, Princeton University, Department of Physics, Jadwin Hall, Princeton, NJ 08544-1098; puchalla@princeton.edu

The Department of Physics at Princeton University has begun testing a stand-alone, one-semester IPLS course tuned to biology majors. The course (PHY108) could potentially serve as an alternate to the current standard two-semester physics sequence for biology majors and premeds. With the understanding that there will be significant gaps in the material covered, the question we hope to explore is what can be taught in one semester such that the various learning goals and student interests are best served. In this talk, I will briefly discuss the motivation, unusual design and implementation of PHY108.

CF10: 5:30-5:40 p.m. Examining the Implementation of a New IPLS Course*

Contributed – David P. Smith, University of North Carolina at Chapel Hill. Department of Physics and Astronomy, Chapel Hill, NC 27599-0001; smithd4@email.unc.edu

Alice D. Churukian, Duane L. Deardorff, Colin S. Wallace, Laurie E. McNeil, University of North Carolina at Chapel Hill

At the University of North Carolina at Chapel Hill, we have completed the inaugural implementation of our new introductory physics course for life science (IPLS) majors. All sections of the course were offered in the new format, utilizing the lecture-studio model developed at Kansas State University[1] and the Colorado School of Mines.[2] The course redesign focused on aligning introductory physics concepts with authentic biological applications. In addition, the pedagogy was largely reformed to include best practices on interactive engagement. We have learned many lessons along the way, ranging from basic logistics to highlighting student difficulties in topics not traditionally taught at this level. In this presentation, we will present an overview of the implementation strategy, in addition to discussing specific examples of noted student difficulties.

*This work has been supported in part by the National Science Foundation under Grant No. DUE-1323008.

1. C.M. Sorensen, A.D. Churukian, S. Maleki, and D.A. Zollman, "The New Studio format for instruction of introductory physics," *Am. J. Phys.* **74**, 1077-1082 (2006).

2. T. Furtak and T. Ohno, "Installing studio physics," *Phys. Teach.* **39**, 11-15 (2001).

CF11: 5:40-5:50 p.m. Social Constructs of Career Persistence in the Introductory Physics Classroom

Contributed – Remy Dou, Florida International University, 11200 SW 8th St., Miami, FL 33199; douremy@gmail.com

In science courses, measures of self-efficacy have been positively correlated with increased student persistence in the face of obstacles, greater likelihood of pursuing a science degree, as well as improved academic performance. Certain classroom interactions may contribute to self-efficacy through one of four recognized sources, two of which—verbal persuasion and vicarious learning—are highly social in nature. In this study, we looked for relationships between students' social classroom interactions and their self-efficacy in an introductory Modeling Instruction Physics course at Florida International University. Social network analysis (SNA) was used to calculate centrality—a proxy for how ingrained a particular student is in the academic social network of the classroom. A correlation was tested between students' centrality and their participation in self-efficacy building activities, as measured by the Sources of Self-Efficacy in Science Courses survey. The results of the analyses contribute to research in support of collaborative-learning science classroom designs.

CF12: 5:50-6 p.m. Fears and Apprehensions of Introductory Physics Students

Contributed – Jon DH Gaffney, Eastern Kentucky University, 2060 Oleander Dr., Lexington, KY 40504; jon.gaffney@eku.edu

Many students are apprehensive when entering a physics classroom for the first time, reporting that they heard that the course is going to be "hard" or otherwise unpleasant. These perceptions may have a negative impact on students' experiences, especially when fears are realized. To better understand the nature of these students' concerns, about a hundred students taking College Physics 1 at Eastern Kentucky University were asked to write down their biggest "dread, fear, or concern" at the start of the semester and then reflect at the end of the semester about whether their biggest fears were realized. Additionally, students completed a survey about how fearful they were about various possible scenarios, such as getting stuck on activities or having their mistakes exposed to the class. Preliminary results are reported, with consideration for factors such as gender and earned grade.

Session CG: Introductory Labs/ Apparatus

Location: SSU - Benjamin Banneker B
Sponsor: AAPT
Date: Monday, July 27
Time: 4–5:40 p.m.

Presider: Eric Ayars

CG01: 4-4:10 p.m. Reforming Calculus-based Introductory Physics Labs at Georgia State University and their Effect on Students' Learning

Contributed – D. G. Sumith P. Doluweera, Georgia State University, 25 Park Place, Atlanta, GA 30303; ddoluweera@gsu.edu

Brian D. Thoms, Joshua Von Korff, Georgia State University

As a comprehensive PhysTEC site, Georgia State University has undertaken a reform of calculus-based introductory physics sequence I and II. Under the course reform, traditional three-hour lab was replaced with a trained undergraduate learning assistant led one-hour tutorial and two hour-guided inquiry based lab conducted by a graduate teaching assistant. Guided inquiry-based new and modified labs were developed and tested with students in two pilot programs in spring 2014 and fall 2014. New labs were fully implemented for calculus-based physics I in fall 2014 and for physics II in spring 2015. Design considerations, students' perspectives of labs and learning gains of students with and without lab reform are discussed.

CG02: 4:10-4:20 p.m. Analyzing the NEXUS/Physics Laboratory Curriculum at UMD and Beyond*

Contributed – Kimberly A. Moore, University of Maryland, 6525 Roosevelt St., Falls Church, VA 22043; MoorePhysics@gmail.com

Wolfgang Losert, University of Maryland

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 in 2013-Present, and adopted at several institutions (including TYCs, R-1 universities, and small 4-year colleges) in 2014-2015. 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 at UMD. We also have survey data from some of the initial adopting institutions. In this talk, we will provide a brief overview of what we have learned and a comparison of our large-enrollment results and the results from "first adopter" institutions to the results from our pilot study.

*This work is supported by funding from HHMI and the NSF.

CG03: 4:20-4:30 p.m. Reproduce Robert Boyle's Air Pump

Contributed – Osamu Matsuno Aichi, University of Arts, 1-114 Tazako sagamine Nagakute, Aichi, Japan 480-1194; o.matsuno@nifty.com

Koji Tsukamoto, Kashiwa Minami High School

How did Robert Boyle perform his experiments? About 350 years ago, Boyle constructed two or three types of air pumps that were used to perform many experiments. His activities were some of the earliest scientific investigations, and his procedures for inquiring into scientific truths became a standard model for future generations.* That is, the people who saw his pump were bearing witness to the birth of modern experimental science. Reproducing his machines and experiments would allow the current generation to experience the birth of modern science for themselves, just as it occurred in Robert Boyle's laboratory. While our reproduction of the pump may appear to be a poor imitation, our aim is not to produce an elaborate replica, but rather to recreate the atmosphere in which it was used.

* Shapin, S., and Shaffer, S., "Leviathan and Air Pump", 1985, p. 25.

Monday afternoon

CG04: 4:30-4:40 p.m. Energy Efficiency vs. Tire Pressure and Rolling Weight in Bicycles

Contributed – Erik Bodegom, Portland State University, Physics Department, Portland, OR 97207-0751; bodegom@pdx.edu

Brody Boeger, Portland State University

Cycling is one of the fastest growing modes of transportation in large cities. As a result, bicycles and their function are of increasing interest to an environmentally minded society. As a mode of transportation, maintenance and efficiency become important aspects of cycling, but are often overlooked by everyday riders. Using a standard bicycle, digital force plates, and a power-metering hub it was possible to quantify the individual and combined effects of decreased tire pressure and increased weight on the bicycle in terms of energy expenditure of the rider. Similar to studies on fuel efficiency in automobiles, having a number that quantifies how difficult it is, i.e., an efficiency measure provides additional motivation for adopting sustainable and healthful transportation.

CG05: 4:40-4:50 p.m. Static and Dynamic Fluid Experiments

Contributed – Kristen A. Thompson, Loras College, 12315 Kingston Way, Dubuque, IA 52001; Kristen.Thompson@loras.edu

Bennett Cook, Loras College

This report describes a system to have students verify the static and dynamic behavior of fluids using low-cost and easy to build equipment. The equipment consists of an open manometer that can be filled with a liquid of choice (or multiple liquids) to demonstrate the relationship between pressure and fluid depth. The manometer can then be used with a small tank (5-gallon bucket) with a valve to provide a way to pressurize the system or introduce flow. Students can test Bernoulli's principle and assumptions of incompressibility in the gas phase. These experiments are appropriate for multiple levels of instruction, such as high school and undergraduate laboratories.

CG06: 4:50-5 p.m. From Dirt Cheap Spectrographs to Molecular Spectroscopy

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

Mark Masters, Jacob Millspaw, IPFW

We examine different ways to perform spectra-based experimentation in physics laboratories. Using a shoebox-sized cardboard box spectrograph, we have students studying atomic spectral lines, Fraunhofer absorption lines of sunlight, transmission of white light through different dye concentrations in water, reflection spectroscopy (of dandelion flowers), and even laser induced Play Doh fluorescence. Using the same basic optical configuration but using better quality components, we have also produced a more expensive spectrograph capable of photographing and examining molecular spectra which can be incorporated into advanced laboratories.

CG07: 5-5:10 p.m. Wavelength Determination of a LASER Using a Macroscopic Reflection Grating

Contributed – Gregory P. Latta, Frostburg State University, 101 Braddock Rd., Frostburg, MD 21532-2303; glatta@frostburg.edu

The usual method of measuring the wavelength of a LASER in the undergraduate physics laboratory is to measure the diffraction pattern produced by a diffraction grating with a microscopic spacing of typically 1x10-6m (1000 lines/mm). Unfortunately, only a few orders of interference are observed and the grating spacing cannot be directly observed or measured. The grating spacing is instead taken as that given by the manufacturer. In this novel experiment a macroscopic reflection grating is used to produce a reflection interference pattern with up to 40 or more orders of interference. The grating spacing of 3.00mm can be directly measured and observed. By directly measuring the grating spacing and the large interference pattern produced, the LASER wavelength can be measured with an error of less than 1%. No special equipment other than the LASER and grating is required.

CG08: 5:10-5:20 p.m. Using Kinematic Equations to Design and Control Linear Motions

Contributed – Frederick J. Thomas, Math Machines, 1014 Merrywood Dr., Englewood, OH 45322; fred.thomas@mathmachines.net

A simple-to-construct motorized cart can move in response to functions entered in forms such as "x = x0 + v0*t + .5*a*t^2", "v = v0 + a*t", "x = 200*sin(pi(2)*t/10)" and more. Classroom uses include an algebra-driven extension to kinesthetic Graph Match activities with motion sensors. Other activities engage students in applying kinematic equations to engineering-style tasks, such as "Design a sequence of equations to make the cart carry an upright AA battery from one end of the track to the other as quickly as possible without the battery falling over." Building instructions, software, and classroom activities will be distributed.

*Supported in part by NSF's Advanced Technological Education Program through grant DUE-1003381. More information is available at www.mathmachines.net.

CG09: 5:20-5:30 p.m. Representation Translation of Vector Fields in the Introductory Physics Laboratory

Contributed – Timothy McCaskey, Columbia College Chicago, 600 S. Michigan Ave., Chicago, IL 60605-1996; tmccaskey@colum.edu

Wilson A. Tillotson, University of Illinois at Chicago

Luis G. Nasser, Columbia College Chicago

Representations of vector fields are prominent in E&M courses. Connecting these fields with quantitative reality in the laboratory is challenging. We have developed a lab that starts with students mapping field lines for various bar magnet configurations and continues with a Hall probe experiment in which students execute a series of scaffolded tasks, culminating in the prediction and measurement of the spatial variation of the field components. Students have more difficulty as these tasks progress; given a field line diagram, they typically can determine the correct direction of the field at any point in space, but in lab, they have trouble breaking field vectors into components and even more difficulty graphing how these components vary along a line. Despite the difficulties, students got better at drawing actual functions for their predictions. We suggest that developing lab activities of this nature brings a new dimension to how students learn field concepts.

CG10: 5:30-5:40 p.m. A LEGO Spectrometer

Contributed – Helio Takai, Brookhaven National Laboratory, Physics Department, Building 510A, Upton, NY 11973; helio.takai@gmail.com

Brittney R. Bothnell, Shelter Island High School

Sara S. LeMar, North Shore High School

Spectroscopy plays an important role in modern physics. Through the observation of emission and absorption spectral lines we learn about the quantum states of atoms and molecules. Often, students are introduced to spectroscopy using commercial spectrometers designed for the classroom. We have developed an affordable optical spectrometer using Lego blocks. The spectrometer uses a homemade concave diffraction grating to analyze light and a webcam to record the spectrum. By removing the webcam's filter the spectrometer sensitivity is extended from 370 nm to 1100 nm. The light is brought to the spectrometer using an optical fiber used in high end audio systems. The use of Lego blocks to build the spectrometer allows for quick modifications, tests and experimentation. The device has a number of concepts in optics that can be explored. The spectrometer performance and resolution will be presented.

Session CH: PER: Diverse Investigations I

Location: John S. Toll Physics Building (PHY) - 1412
Sponsor: AAPT
Date: Monday, July 27
Time: 4–5:50 p.m.

Presider: Mila Kryjevskaia

CH01: 4-4:10 p.m. Examining the Effects of Testwiseness Using the Force Concept Inventory

Contributed – Seth T. DeVore, West Virginia University, 45 Grandview Ave., Morgantown, WV 26506-0002; 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) that contain distractors, the selection of which can be related to the use of testwiseness strategies. We further examine the effects of both the positive and potential negative effects of testwiseness on student scores by developing two modified versions of the FCI designed to include additional elements related to testwiseness. Details of the development of the modified versions of the FCI and the effect sizes measured in all versions of the FCI will be discussed.

CH02: 4:10-4:20 p.m. Influence of Language of Administration Upon Physics Concepts Measuring Instruments

Contributed – Thomas Olsen, Alfaisal University, PO Box 50927, Riyadh, Rihadh, 11533 Kingdom of Saudi Arabia; tolsen@alfaisal.edu

Mohamed S. Kariapper, Alfaisal University

The Force Concept Inventory (FCI) has become a world standard as an instrument to measure students' conceptual understanding of Mechanics. In particular, the Normalized Gain has proven to be a robust measure of the effect of pedagogy upon student learning. While the original FCI was developed in English, translations have been made. In this study seeks to determine the effect, if any, of administering the FCI in different languages to different groups of students, taken from the same student population. As an English language university in Riyadh, Saudi Arabia, Alfaisal University is an excellent laboratory for such a study. The FCI has been administered to all introductory physics students at Alfaisal, at the beginning and the end of the first physics course spring 2015 semester. The students were randomly assigned English and Arabic administrations. Results for the first semester of this study will be presented along with preliminary analysis.

CH03: 4:20-4:30 p.m. Rasch Analysis of Student Responses to the CLASS

Contributed – Xi Tang, Texas State University, 1975 Aquarena Springs Dr., San Marcos, TX 78667-0747; x_t4@txstate.edu

David Donnelly, Texas State University

The Colorado Learning Attitudes about Science Survey (CLASS) has become a standard instrument for assessing changes in student attitudes. The standard data analysis protocol compares student responses to those of experts, and assigns a percentage ranking to each respondent. This analysis assumes students fall on a continuum from novice to expert. Another analysis model, the Rasch Model, is also based on this assumption. The Rasch Model also provides information about survey items simultaneously with information about respondents. For this reason, the Rasch Model provides an alternate, and perhaps more robust, method of analyzing CLASS data. To compare the Rasch Model to the traditional analysis methods, we have applied the Rasch Model to data that had been previously analyzed using the protocol developed at the University of Colorado. We will present the results of the Rasch Analysis, and discuss the differences between it and the standard analysis.

CH04: 4:30-4:40 p.m. Integrating Scientific Practices into Introductory Physics Assessments

Contributed – James T. Laverty, Michigan State University, 620 Farm Lane, Room 115, East Lansing, MI 48824-1046; laverty1@msu.edu

Stuart H. Tessmer, Sonia M. Underwood, Melanie M. Cooper, Marcos D. Caballero, Michigan State University

The Physics and Astronomy Department at Michigan State University recently began to redesign its introductory physics courses. At the center of this transformation effort is an attempt to include scientific practices, crosscutting concepts, and core ideas in the assessments and instruction of the courses. As part of a research effort, we have been developing the Three-Dimensional Learning Assessment Protocol (3D-LAP) to characterize how assessments used in introductory courses change over time. This instrument provides criteria by which scientific practices, crosscutting concepts, and core ideas can be identified within assessment items. Additionally, this instrument can be used to help write new assessment items or improve existing ones. This presentation will focus on the 3D-LAP and using it to track changes in assessments over time as well as to build assessment items that incorporate all three dimensions.

CH05: 4:40-4:50 p.m. AACR: Probing Student Thinking with Computer Analyzed Constructed Response Questions

Contributed – Matthew M. Steele, Michigan State University, 320 S Magnolia Ave., Lansing, MI 48912; steele24@msu.edu

Mihwa Park, Mark Urban-Lurain, Michigan State University

Constructed response questions (short-answer, open-ended items) have the potential to provide more insight on student thinking than the multiple choice questions often employed in large introductory STEM courses. However, the time and costs associated with the evaluation and analysis of large data sets of constructed response has traditionally been a barrier to their adoption. In an effort to provide instructors with greater insight into their student understanding of core STEM concepts the Automated Analysis of Constructed Response (AACR, www.msu.edu/~aacr) Research Group is working to create a system for the automated analysis of student constructed responses. In this presentation we present recent work developing constructed response items to evaluate students understanding of foundational concepts in physics and astronomy, and discuss preliminary results produced by these items.

CH06: 4:50-5 p.m. How Accurate Are Students in Gauging Changes in their Understanding?*

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

Therese Claire, Western Washington University

Sara Julin, Whatcom Community College

Mila Kryjevskaia, North Dakota State University

MacKenzie Stetzer, University of Maine

Research over several decades has shown that active self-monitoring is characteristic of expert learners. More recent studies have examined student metacognition in introductory physics contexts. As part of a multi-institutional collaborative effort, we have been investigating reflective metacognition – student ability to describe in hindsight what they have learned about a specific physics concept, and how they have learned it. We are interested in how student descriptions of their own learning compare with how instructors might evaluate their learning. Our methodology involves matched written assessment questions given at the start and end of a learning episode. After the post-test, students reflect on how their thinking has changed. Comparison of self-reported and researcher-characterized changes allows the accuracy of student reflections to be examined. The study design was described in a presentation at the Winter 2015 AAPT meeting in San Diego; the current talk shares preliminary results.

*This work partially supported by NSF DUE-1245999, DUE-1245993, DUE-1245313 and DUE-1245699.

CH07: 5-5:10 p.m. Expert/Novice Differences in Viewing Physics Diagrams Using the "Flicker" Technique

Contributed – Jason W. Morphew, University of Illinois, 255 Loomis Laboratory, 1110 West Green St., Urbana, IL 61801; jmorphe2@illinois.edu

Jose P. Mestre, Brian H. Ross, University of Illinois

We present an experiment in which subjects with differing levels of physics experience were timed in their ability to detect small changes in nearly identical pairs of diagrams that are representative of typical introductory physics situations. It was hypothesized that higher physics expertise would guide attention and result in faster detection times for those changes that affected the physics, whereas no expertise advantage in detection times would result for changes that did not affect the physics. Our findings partially confirmed the hypothesis. We present results on how the response time for noticing physics-relevant changes in the diagram pairs is faster than for physics-irrelevant changes for those with more extensive physics experience and slower for those with less extensive physics experience. We discuss the cognitive implications of our findings.

CH08: 5:10-5:20 p.m. Quantifying School Students' Reasoning Abilities*

Contributed – Gordon J. Aubrecht, Ohio State University at Marion, 1465 Mt. Vernon Ave., Marion, OH 43302-5695; aubrecht.1@osu.edu

Jennifer L. Esswein, Education Northwest

Jessica G. Creamer, Education Specialist

Bill Schmitt, Science Center of Inquiry

Middle school teachers in our program give students pre- and post-common formative assessments (CFAs) and analyze them. We created a rubric to assess student communication, correctness, use of evidence, and reasoning on the CFAs. We will present results of our analysis of samples of students of control and treatment teachers.

*This work supported in part by grants from the Ohio Department of Education C1457-OSCI-09-49 (2008-2009), C1667-MSP-10-410 (2009-2010), EDU01-0000006141 (2010-2011), EDU01-0000007902 (2011-2012), GRT00029161 (2012-2013), ODE-MSP-10673 (2013-2014), and EDU01-0000013704 (2014-15).

CH09: 5:20-5:30 p.m. Why Do Students Want to Distinguish Between Net Force and Total Force?

Contributed – Philip B. Southey, University of Cape Town, Physics Department, Western Cape, 7700 South Africa; philsouthey@gmail.com

Saalih Allie, University of Cape Town

In previous research we have shown that novice physics students distinguish between the concept of a net vector quantity and the concept of a total vector quantity. Introductory physics textbooks variably use the terms "net", "total" or "resultant" when referring to a vector sum, with some textbooks using these terms interchangeably. In particular, we have shown that students distinguish between the concepts of net force and total force, and the concepts of net momentum and total momentum. Phase two of this research has been to analyze the reasons students give for making these distinctions. Using an approach suggested by Grounded Theory, free responses from 400 freshmen have been analyzed and broad reasoning trends have been identified. These trends are contrasted with foundational representational schemas posited by the cognitive sciences, such as "changing position versus changing state", and "interior viewpoint versus exterior viewpoint".

CH10: 5:30-5:40 p.m. Teaching Weight and Gravitation as Cultural Content Knowledge

Contributed – Igal Galili, The Hebrew University of Jerusalem, Science Teaching Center, Givat Ram Campus, Jerusalem, 91904 Israel; igal.galili@mail.huji.ac.il

There is a split in teaching the concepts of weight and gravitation in physics education (Galili, 2001). One group of physics teaches weight as the gravitational force within the developed Newtonian framework (e.g. Young and Freedman, 2012). The second group adopts the modern framework based on the operational definition of weight (e.g. Knight, 2013). Normally the authors in each group ignore the other view. We suggest teaching weight within the cultural perspective (Galili, 2012) which displays the two options and argues for the modern one – the operationally defined weight which does not coincide with the gravitational force. We have performed a comprehensive study on this subject (Stein, 2012) which included teaching experiments in which we applied a constructivist dialogical teaching of the topic of Weight-Gravitation. Our findings showed the ability of students to distinguish between weight and gravitation and meaningfully understand these concepts (Stein & Galili, 2014).

CH11: 5:40-5:50 p.m. Probing Students' Experiences in the First Year Physics Laboratory

Contributed – Maria Munene Tlowana, University of Cape Town, Physics Department, Rondebosch, 7701 South Africa; mmtlowana@gmail.com

Saalih Allie, University of Cape Town

As part of a broader study aimed at understanding the first-year laboratory experience from various perspectives, we report on a pilot study in which we probed students' perceptions of the first-year lab course at the end of the first term. For this purpose we developed a written instrument comprising five questions regarding the following areas of interest: expectations, enjoyment, learning, relation to course content, and assessment. Each question on the instrument is framed as a debate in which different points of view were posited. The respondents were requested to choose the view with which they most closely agreed (forced choice response), and more importantly, were directed to explain their choice in detail (free response writing). We detail the analysis and report on some of the preliminary findings focusing on the aspects of enjoyment and the learning experience.

Session CI: PER: Identity and Student Engagement

Location: SSU - Atrium
Sponsor: AAPT
Date: Monday, July 27
Time: 4–5:50 p.m.

Presider: Amy Robertson

CI01: 4-4:10 p.m. Dealing with Stereotype Threat in Physics Identity Development

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

As part of a larger study on physics identity development, we have observed that students link their academic achievements and social interactions in physics to their sense of belonging in physics. For students who identify with underrepresented groups in physics, stereotype threats can be a significant obstacle to "feeling like a physicist" because students belong to multiple communities with identities that are often at odds with one another. As representatives of their community, these students have to deal with the added worry of confirming the stereotypes about their group. For example, female majors may feel that they have to prove that women aren't bad at math. Through interviews with upper-division physics majors, we examined coping strategies to deal with stereotype threat in a variety of settings. Our findings suggest that peers and mentors can play unexpected roles in helping students manage stereotype threat and succeed in becoming physicists.

CI02: 4:10-4:20 p.m. Exploring Self-Efficacy and Growth Mindset Through Overlapping Interests Projects

Contributed – Vashti A. Sawtelle, Michigan State University, 867 Wilson Rd., East Lansing, MI 48824-1046; vashti.sawtelle@gmail.com

Angela Little, Michigan State University

Educational psychology studies have linked self-belief constructs to success in STEM, including self-efficacy (the belief in one's ability to succeed at specific tasks) and growth mindset (seeing intelligence as something that can be developed through dedication and effort). However, most of the work with these constructs uses traditional psychology large-N quantitative studies that show that change happens without describing in qualitative detail the mechanism by which it happens. This presentation will focus on a likely place for students to have a self-efficacy and growth mindset building experience: an in-depth course project that students complete in conjunction with introductory physics. We present evidence of students who see themselves as competent in neuroscience or genetics, who identify as people who embrace challenge, but who still place physics in a category of special difficulty. We then explore how this overlapping interests project creates opportunities to impact self-efficacy and growth mindset in physics.

CI03: 4:20-4:30 p.m. Investigation of Physics Identity Within a Classroom Social Network

Contributed – Eric A. Williams, Florida International University, 11200 SW 8th St. - CP 204, Miami, FL 33199; ewill085@fiu.edu

Eric Brewe, Geoff Potvin, Zahra Hazari, Laird Kramer, Florida International University

Students from traditionally underrepresented backgrounds in the United States face unique challenges across the Science, Technology, Engineering, and Math (STEM) fields, but the situation in physics is especially concerning: of all the physics bachelor degrees awarded nationwide, only 4% go to Hispanic students. This problematic level of participation can be investigated through the construct of physics identity, or how strongly a student "feels like a physics person," which has been shown to be correlated with the likelihood of choosing a physics career. Because physics identity may be impacted by a student's social interactions, Network Analysis may be used to explore the relationship between a student's calculated centrality —a measure of how embedded or "central" a particular student is within the classroom social network—and their physics identity. In this study, we investigate this relationship for students in a collaborative-learning Modeling Instruction introductory physics course at Florida International University.

CI04: 4:30-4:40 p.m. Determining Strategies that Predict Physics Identity: Emphasizing Recognition and Interest

Contributed – Robynne M. Lock, Texas A&M University-Commerce, PO Box 3011, Commerce, TX 75429; robynne.lock@tamuc.edu

Zahra Hazari, Geoff Potvin, Florida International University

Although the number of students earning bachelor's degrees in physics has increased, the percentage of those degrees earned by women has not increased for more than 10 years. We use a physics identity framework to understand the factors that may impact physics career choice. Physics identity consists of three dimensions: recognition (perception of recognition by others), interest (desire to learn more), and performance/competence (perception of ability to understand). Our previous work has shown that recognition and interest are more significant predictors of physics career choice than performance/competence, and that women may require more recognition than men in order to choose physics careers. Therefore, teaching strategies that specifically target recognition and interest should be identified. Using data from a survey administered to a nationally representative sample of college students, we use regression models to determine which teaching strategies predict recognition and which strategies predict interest.

CI05: 4:40-4:50 p.m. A Longitudinal Investigation of Informal Learning Community

Contributed – Yuehai Yang, California State University, Chico, 343 W 1st Ave., Chico, CA 95926; yyang34@csuchico.edu

Binod Nainabasti, David T. Brookes, Eric Brewe, Florida International University

Chris Kaneshiro, California State University, Chico

In consecutive semesters, students from a second-semester introductory college physics course have been asked to report who they worked with on physics outside class time. In the first semester, the course was taught in a traditional lecture class setting. In the second semester the course was taught by the same instructor with similar class size, implementing aspects of Investigative Science Learning Environment (ISLE) where students worked collaboratively in group learning activities. Our study suggests that implementing an in-class interactive learning environment can help foster the informal learning community outside of the classroom. Using social network analysis, we have analyzed the relationship between students' positions in the informal learning communities formed outside the classroom with their performance in the course. Our results indicate that being integrated into the informal learning community outside of the classroom can help students, especially "weaker" ones, to succeed in their introductory physics courses.

CI06: 4:50-5 p.m. How Undergraduate Research Experiences Support More Central Participation in Physics

Contributed – Gina M. Quan, University of Maryland, 082 Regents Dr., College Park, MD 20740; gina.m.quan@gmail.com

Undergraduate research has been recognized as a significant way to facilitate undergraduate students' more central participation in physics. In this talk, I will present a potential mechanism by which research experiences may impact undergraduate participation: changes in their beliefs about the nature of science coupled to changes in a sense of ability to contribute to authentic research. Students in the study were part of a research seminar at the University of Maryland in which they worked with faculty and graduate student research mentors on research projects. Class time was dedicated to developing research skills and supporting students through emotional hurdles associated with research. In videotaped interviews, we asked students to describe their experiences in research. Students developed nuanced views about how the research process works. They also perceive shifts in their sense of access to research, feeling like their contributions as novices mattered.

CI07: 5-5:10 p.m. Research and Development of PhET Simulation-based Physics Tutorials

Contributed – Vijay R. Kaul, University of Maryland, College Park, 082 Regents Dr., College Park, MD 20742-2421; vijay@umd.edu

Well-designed instructional simulations in the classroom can help students learn difficult concepts in an enjoyable way. The University of Colorado PhET simulations are some of the most widely used (15 million runs every year). We are investigating students' reasoning when working collaboratively on PhET simulations scaffolded by tutorial worksheets. We have developed a tutorial for the Gas Properties simulation for introductory physics students designed to solicit mechanistic reasoning about temperature and pressure in terms of molecular motion. However, in clinical and classroom settings, students working collaboratively on the tutorial used the ideal gas law to make predictions about situations in which an ideal gas is being compressed or heated and subsequently used the simulation to confirm their predictions. Many groups did not engage in discussing the temperature, pressure or work done in terms of the molecular motion. These results informed subsequent modifications. We will present preliminary results of our investigations.

CI08: 5:10-5:20 p.m. Traditional Physics Versus IPLS: Comparing Student Interest and Engagement*

*Contributed – Tessa E. Williams,** Swarthmore College, 500 College Ave., Swarthmore, PA 19081; twillia4@swarthmore.edu*

Benjamin H. Geller, K. Ann H. Renninger, Catherine H. Crouch, Swarthmore College

Chandra Turpen, University of Maryland

Swarthmore College life science students take a traditional first semester physics course, but have the option of taking an innovative Introductory Physics for the Life Sciences (IPLS) course in the second semester. This curricular structure presents a unique opportunity to compare students' experiences across these different instructional environments. We have used multiple conceptual and attitudinal survey instruments, and have interviewed a number of students over the course of the year, in an effort to assess students' evolving relationship with physics across these two different experiences. In this talk we present some of our findings from these survey and interview data, comparing epistemological and affective features of students' experiences across the traditional and IPLS environments. This comparison allows us to identify some of the features that students find especially engaging about the IPLS course in particular.

*Work supported in part by Swarthmore College and by the Howard Hughes Medical Institute Science Education grant to Swarthmore College.

**Sponsored by Catherine Crouch

CI09: 5:20-5:30 p.m. Unpacking the Source of Student Interest in an IPLS Course

Contributed – Benjamin Geller, Swarthmore College, 500 College Ave., Swarthmore, PA 19070; bgeller1@swarthmore.edu

Chandra Turpen, University of Maryland, College Park

Ann Renninger, Panchompoo Wisittanawat, Catherine Crouch, Swarthmore College

Effectively teaching an Introductory Physics for the Life Sciences (IPLS) course means engaging life science students in a subject for which they may not have considerable preexisting interest. We have found that the inclusion of authentic life science examples supports students whose initial interest in physics is less developed, but that different examples and models vary in their effectiveness at engaging student interest. In this talk we begin to unpack this variability, exploring why some life science examples may be more successful than others at sparking and sustaining student interest. By analyzing data from (1) survey instruments assessing student interest in particular life science examples, and (2) interviews conducted with students before and after instruction, we identify features of our IPLS course that appear to be particularly important for fostering student engagement. We suggest that some of these features might also foster student interest in more traditional introductory physics courses.

CI10: 5:30-5:40 p.m. Implementing Spaced Recall in Introductory Physics

Contributed – Eugene T. Torigoe, Thiel College, 169 Reynolds Ave., Meadville, PA 16335; etorigoe@thiel.edu

Psychological research about human memory has shown the effectiveness of spaced recall.[1] This research has demonstrated that attempting to recall information leads to stronger memory, than being told of rereading the information. In this talk I will describe how I have tried to incorporate spaced recall in my classes, and the ways it aids me as an instructor to make pedagogical decisions. I will also speculate on the cognitive skills that may aid student recall.

1. Brown, Peter C., Henry L. Roediger III, and Mark A. McDaniel. *Make it stick.* Harvard University Press, 2014.

CI11: 5:40-5:50 p.m. Developing SPOT: A Tool for Understanding Student Engagement STEM Classrooms

Contributed – Katrina Roseler, San Jose State University, One Washington Square, San Jose, CA 95192-0001; katrina.roseler@sjsu.edu

Cassandra Paul, San Jose State University

Cara Harwood Theisen, University of California Davis

While many instructors are interested in implementing student-centered practices in their classroom, few have access to data from their classroom to make informed instructional decisions. Our research team has developed the Student Participation Observation Tool (SPOT), an innovative web-based application, developed based on observable classroom actions aligned with research-based instructional practices. Using the SPOT, observers collect observational data that can be used by instructors to identify desirable classroom interaction sequences as well as illuminate areas for possible improvement. Armed with data, instructors are able to make informed decisions about their teaching practice and implement desired changes aligned with research-based best practices. This presentation describes the methods used to identify research about best practices in teaching as well as the process of distilling the observable actions and modes of engagement included in SPOT. We will also discuss how session participants can access the SPOT in order to try it out.

Session CJ: PER in the Upper Division II

Location: John S. Toll Physics Building (PHY) - 1410
Sponsor: AAPT
Date: Monday, July 27
Time: 4–6 p.m.

Presider: Mary Bridget Kustusch

CJ01: 4-4:10 p.m. Investigating Quantitative Reasoning Skills in Upper Division Math Methods*

Contributed – Michael E. Loverude, Department of Physics, MH611, Cal State Fullerton, Fullerton, CA 92834; mloverude@fullerton.edu

Many upper-division physics courses have as goals that students should "think like a physicist." Among other things, these goals include quantitative reasoning skills: considering limiting cases, dimensional analysis, and using approximations. However, there is often relatively little curricular support for these practices and many instructors do not assess them explicitly. As part of a collaborative project to investigate student learning of mathematics in upper-division courses including the traditional "math methods" course, we have developed a number of written questions to investigate these skills. Although there are limitations to assessing these skills with written questions, they can provide insight to the extent to which students can apply a given skill when prompted, even if they do not help understand how and when students choose to activate these skills. Examples of student responses will be provided.

*Supported in part by NSF grant 1406035.

CJ02: 4:10-4:20 p.m. A Sophisticated Learner's View of the Connection between Mathematics and Quantum Mechanics

Contributed – Vesal Dini, Tufts University, 212 College Ave., Medford, MA 02155; vesal.dini@tufts.edu

Students' physical intuitions and prior knowledge are critical to making sense of and solving problems in classical mechanics. In quantum mechanics (qm), coordinating concepts connected to everyday thinking becomes more difficult. How then can students develop coherence in their knowledge of qm? Consider how experts do it: they build meaning in, around, and through the mathematics of the theory. This view on the role of mathematics in the pursuit of knowledge is part of a larger set of views that constitute someone's personal epistemology. The experts' view noted above, which is one among many possible to take, seems most productive for qm. In our work to characterize student epistemologies that emerge in the context of qm coursework, we came to analyze one student who mostly adopted such a view until a shift in context moved him to express an alternative. We present his case and discuss important implications for instruction.

CJ03: 4:20-4:30 p.m. Investigating Student Difficulties with Position and Momentum Representations in Quantum Mechanics*

Contributed – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

Quantum mechanics is challenging even for advanced undergraduate and graduate students. We have been investigating the difficulties that these students have with position and momentum representations in quantum mechanics. We administered written free-response and multiple-choice questions to students to investigate the difficulties. We find that many students struggle with these concepts and share common difficulties.

*This work is supported by the National Science Foundation.

CJ04: 4:30-4:40 p.m. Student Difficulties with the Probability of Measuring Position and Energy in Quantum Mechanics

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

Emily Marshman, University of Pittsburgh

Quantum mechanics is challenging, even for advanced undergraduate and graduate students. We have been investigating the difficulties that students have in determining the probability of measuring position and energy as a function of time when the initial wavefunction is explicitly given. We find that many students struggle with these concepts. We discuss some common difficulties. This work is supported by the National Science Foundation.

CJ05: 4:40-4:50 p.m. Investigating and Improving Student Understanding of Perturbation Theory in QM

Contributed – Gina Passante, University of Washington, Department of Physics, Seattle, WA 98195-0001; passante@uw.edu

Paul J. Emigh, Tong Wan, Peter S. Shaffer, University of Washington

Over the past several years the Physics Education Group at the University of Washington has been working to probe the difficulties students encounter with time-independent perturbation theory and has been developing tutorial curriculum to improve student understanding. Perturbation theory is often taught near the end of a junior-level quantum mechanics course. It is an important topic as it allows the solutions to the Schrödinger equation for simple potentials to be used to approximate solutions for more complicated, and often more physically realistic, potentials. In this talk I will discuss some of the changes to curriculum we have made over the last few years to improve student understanding. This investigation has also illuminated difficulties that students have in interpreting graphically the inner product of functions.

CJ06: 4:50-5 p.m. Developing a Quantum Interactive Learning Tutorial (QuILT) on the Double-slit Experiment

Contributed – Ryan T. Sayer, University of Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15260; RTS36@pitt.edu

Alexandru Maries, Chandralekha Singh, University of Pittsburgh

Learning quantum mechanics is challenging even for upper-level undergraduate students and graduate students. Interactive tutorials that build on students' prior knowledge can be effective tools to enhance student learning. We have been investigating student difficulties with the quantum mechanics behind the double-slit experiment and have developed a Quantum Interactive Learning Tutorial (QuILT) that makes use of a simulation to improve their understanding. We describe the common student difficulties with the double slit experiment and the extent to which the QuILT was effective in addressing these difficulties. We thank the National Science Foundation for support.

CJ07: 5-5:10 p.m. Reinforcement Effects on Student Understanding of Quantum Mechanical Concepts

Contributed – Charles Joseph DeLeone, California State University San Marcos, Physics Department, 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 of quantum concepts with tools such as the QMCA have exposed challenges associated with student learning of concepts such as superposition and time evolution of states. But does student learning of these concepts persist and/or improve with further exposure to quantum concepts in a second semester course? This talk presents the results of a study of upper-division students that addresses this question. Results concerning the robustness of student understanding of quantum concepts across representations and systems will also be discussed.

CJ08: 5:10-5:20 p.m. Embodied Action of Small Groups Answering the Quantum Mechanics Survey

Contributed – Aureliano Perez, Texas State University, 601 University Dr., San Marcos, TX 78666-4615; hgclose@txstate.edu

Martin Lawler, Hunter G. Close, Texas State University

The Quantum Mechanics Survey (QMS) is a research-based assessment of student understanding of quantum mechanics in one dimension.[1] In a first upper-division course in quantum mechanics, we observed students working in isolated small groups to answer the QMS. Students in this class were instructed in an interactive lecture environment in which spatial visualization and gesture were encouraged. An understanding of the complex relative phase factor between components of a state is useful for some items on the QMS, and was meant to be enabled by the instructional use of pipe cleaners, which provide access to an "out-of-the-board" component for graphing wave functions. Previous studies[2] have shown that students can make substantive use of their bodies and material surroundings to think spatially about quantum mechanics. In this talk we present an overview, with some examples, of students' embodied action as a means for thinking about the QMS.

1. G. Zhu & C. Singh, *Am. J. Phys.* **80**(3), 252-259 (2012).

2. H. Close, C. Schiber, E. Close, and D. Donnelly, presented at the Physics Education Research Conference 2013, Portland, OR, 2013, WWW Document, (http://www.compadre.org/Repository/document/ServeFile.cfm?ID=13115&DocID=3664).

CJ09: 5:20-5:30 p.m. PER in Graduate Level Quantum Mechanics and Guided Group Work

Contributed – Christopher D. Porter, The Ohio State University, 191 W. Woodruff Ave., Columbus, OH 43210; porter.284@osu.edu

Andrew Heckler, Abigail M. Bogdan, The Ohio State University

We are beginning to do PER at the graduate level at OSU, beginning with the graduate quantum mechanics course. A number of prevalent misconceptions and misunderstanding have been identified for undergraduates. A handful of studies have even looked at graduate quantum mechanics. We begin this project by verifying the presence of the difficulties already identified, and looking for new ones with pre/post testing done at the beginning and end of each semester. We review our findings. We also discuss our efforts to overcome these difficulties using guided group work. These weekly meetings are not mandatory except for a small subset of students, but are open to all students in the course. We present example content and give an overview of our approach. Although numbers are low, we make an effort to determine the effectiveness of these guided group work sessions using student attendance, student feedback, and weekly topical pre/post quizzes.

CJ10: 5:30-5:40 p.m. Investigating Transfer of Knowledge in an Upper-level Quantum Mechanics Course*

Contributed – Alexandru Maries, University of Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15260; alm195@pitt.edu

Ryan Sayer, 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 knowledge 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 transfer of knowledge of concepts students had learned in 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 their knowledge gained in that context to another context involving the double-slit experiment.

*Work supported by the National Science Foundation.

CJ11: 5:40-5:50 p.m. Learning from Mistakes in Upper-Level Quantum Mechanics*

Contributed – Benjamin R. Brown, University of Pittsburgh, 100 Allen Hall, Pittsburgh, PA 15260; brb10@pitt.edu

Chandralekha L. Singh, University of Pittsburgh

Andrew Mason, University of Central Arkansas

Helping students learn to think like a physicist is an important goal of many physics courses. One characteristic of physics experts is that they have learned how to learn and they use problem solving as an opportunity for learning. In particular, physics experts automatically reflect upon their mistakes in their problem solution in order to repair, extend and organize their knowledge structure. Unfortunately, for many students, even in an upper-level physics course, problem solving is a missed learning opportunity. We investigated how well students in upper-level quantum mechanics learn from their mistakes and perform in the final exam when provided with explicit incentives to correct their mistakes in the midterm exams compared to those who were not given explicit incentives to correct their mistakes. Findings will be discussed.

*This work is supported by the National Science Foundation.

CJ12: 5:50-6 p.m. Upper-Division Quantum Students' Development in Physics and Mathematics

Contributed – John D. Thompson, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; esayre@gmail.com*

Carlos Trallero, Ulas Ustun, Eleanor C Sayre, Kansas State University

As part of a larger study on how students' mathematical skills co-develop with their physics identities, we examine students' problem solving in upper-division Quantum Mechanics. Over a three-year span in which the course moved from highly traditional lecture to frequent bursts of in-class problem solving, we collected conceptual survey data on students' math skills and understanding of quantum topics. Additionally, we observed students ' problem-solving activities during class time. We present evidence of students' developing ideas about the nature of physics and physics problem-solving as they travel through the course.

*Sponsored by Eleanor Sayre

Session CK: Carnival Knowledge

Location: SSU - Prince George's
Sponsor: Committee on Physics in Pre-High School Education
Date: Monday, July 27
Time: 4–5 p.m.

Presider: Jan Mader

CK01: 4-4:30 p.m. Carnival Knowledge: The Flying Bernoulli Brothers' Stupendous Sideshow of Science – Part I*

Invited – Eugene Easter, Brushfire Science, 540 S. Ridgecliff St., Tallmadge, OH 44278; gleaster@sbcglobal.net

Hurry! Hurry! Hurry! To the Greatest Show and Tell on Earth! Take a stroll down the Magic Midway as the Flying Bernoulli Brothers explore the games of chance—or so they are called. How do they work? Learn how to play using scientific principles. See when to bet and when not. See how they gaff a game. What are alibi games? Why are Flat Stores flat? Participants will actually try many of the games as we explain how the principles of physics are used against you. Hanky Panks, Group Games, Skill Games, Percentage Games, Buildup, Alibi, Flat Stores and more.

*Funded by Misspent Youth

CK02: 4:30-5 p.m. The Flying Bernoulli Brothers Present Carnival Knowledge – Part 2*

Invited – William Reitz, retired, 2921 Kent Rd., Silver Lake, OH 44224; wreitz@neo.rr.com

A continuation of Carnival Knowledge: The Flying Bernoulli Brother's Stupendous Sideshow of Science –Part 1.

* Sponsored by Misspent Youth

Session CL: Physics Majors and Careers

Location: SSU - Charles Carroll B
Sponsor: AAPT
Date: Monday, July 27
Time: 5:10–5:50 p.m.

Presider: Anne Cox

CL01: 5:10-5:20 p.m. PRISM: Developing a Student-Led Peer-Mentoring Program for Undergraduate Physics Majors

Contributed – Manher Jariwala, Boston University, Department of Physics, 590 Commonwealth Ave., Boston, MA 02215; manher@bu.edu

Emily Ghosh, Molly Herman, Boston University

We describe a new, student-led, peer-mentoring program at Boston University for undergraduate physics majors called PRISM (PeeRs for Incoming Physics Majors). We discuss the process of working with undergraduates in initiating the effort and developing the goals of the program. We also detail the resulting structure of the program, featuring one-to-one meetings between upper-class mentors and first-year mentees, and the measurement of mentee attitudes regarding comfort, confidence, and identity as a physics major, at different points in their first year on campus. Throughout, we focus on the ownership role of students in this program and its impact on the undergraduate physics learning community within our department.

CL02: 5:20-5:30 p.m. Impact of Physics Modeling Instruction Workshops on Physics Major Production

Contributed – Idaykis Rodriguez. Florida International University, 11200 SW 8th St,, Miami, FL 33199; irodr020@fiu.edu

David Jones, Florida International University

Over the past 10 years, Florida International University (FIU) has conducted summer Modeling Instruction workshops for high school physics teachers. The workshops have impacted teachers and also influenced the number of physics majors at FIU coming from these participating high schools. We collect data of physics majors at FIU for the past 10 years and determine which of these majors come from high schools participating in the Modeling workshops. Out of the 56 schools that participated in the Modeling workshops, 29 of the schools have produced over 90 physics majors, where 40% of those majors come from five high producing schools. The physics teachers at these schools have long-standing ties with the FIU physics community by participating in all three Modeling workshops, monthly Fizmo meetings, and communicating with FIU faculty and staff. We also present interviews of teachers commenting of the strengths of FIU and local high school partnership.

CL03: 5:30-5:40 p.m. Career Moments in Physics: A New Curriculum*

Contributed – Erin De Pree, St Mary's College of Maryland, 18952 E. Fisher Rd., St. Mary's City, MD 20686-3001; ekdepree@smcm.edu

The physics community has many excellent resources on careers in and/or using physics. However, undergraduate students and many instructors are unaware of these resources or even of possible career paths with a physics degree. Over the last five years, I developed this curriculum on careers and research experience that is easy to use and engages students in the exploration of their options. The curriculum consists of 10 short presentations in class, followed by a brief homework assignment. Topics include: finding summer research opportunities, writing a resume, finding job listings, research masters programs, exploring PhD programs and more. After working through Career Moments in Physics, students are prepared to apply for summer research programs and have learned about many of the career options they have and how to further explore their options. The entire curriculum is available online.*

*Curriculum website: sites.google.com/a/smcm.edu/careermomentsphysics

CL04: 5:40-5:50 p.m. Identifying Important 21st Century STEM Competencies Based on Data of Workplace

Contributed – Hyewon Jang, Harvard University, 900 Memorial Dr., Cambridge, MA 02138; hwjang@seas.harvard.edu

This study identifies important competencies for students who consider STEM careers to succeed in the 21st century workforce and educators who consider educational reform. We accomplished an analysis of standardized job-specific database operated and maintained by the U.S. Department of Labor. We specifically analyzed ratings of the importance of skills, knowledge, and work activities. Based on mean values on the importance level, we identified 18 skills, seven categories of knowledge, and 27 work activities as important descriptors to STEM workers and verified statistically significant importance. We categorized our results into a framework drew from Katz and Kahn (1978) and verified inter-rater reliability for categorization. We discuss essential elements of STEM education comparing with frameworks of 21st Century Skills.

Session CM: Interactive Lecture Demonstrations – What's New? ILDs Using Clickers and Video Analysis

Location: SSU - Charles Carroll B
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Educational Technologies
Date: Monday, July 27
Time: 4–5 p.m.

Presider: Priscilla Laws

CM01: 4-4:30 p.m. Interactive Lecture Demonstrations: Active Learning in Lecture Including Clickers and Video Analysis

Invited – David R. Sokoloff, Department of Physics, University of Oregon, Eugene, OR 97403; 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.

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).

CM02: 4:30-5 p.m. Interactive Lecture Demonstrations: Effectiveness in Teaching Concepts

Invited – Ronald Thornton, Tufts University, 12 Temple St., Medford, MA 02155; 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).

TOP05: Physics and Society

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Science Education for the Public
Date: Monday, July 27
Time: 6–7:30 p.m.

Presider: Brian Jones

Join your colleagues for an informal discussion about physics-related societal issues such as climate change, energy use, nuclear power, nuclear weapons, resource extraction, and pseudoscience. Share your ideas about effectively teaching these issues and communicating such information to the general public, and hear what others are doing as well.

TOP06: Graduate Student Topical Discussion

Location: SSU - Benjamin Banneker B
Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 27
Time: 6–7:30 p.m.

Presider: Benjamin Van Dusen

This session is the primary opportunity for members of the PER graduate students community to meet and discuss common issues.

TOP07: Proposed AAPT Governance Changes I

Location: SSU - Juan Ramon Jimenez
Sponsor: AAPT
Date: Monday, July 27
Time: 6–7:30 p.m.

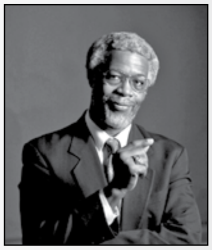
Presiders: Mary Mogge, Beth Cunningham

Although AAPT's executive office is currently located in College Park, MD, the Association has been incorporated in the state of New York since 1957. Recently, the New York State Legislature passed the Nonprofit Revitalization Act of 2013 and the new act became effective on July 1, 2014. Much of AAPT's governance is in compliance with the new act. However, there are some important changes that AAPT needs to make in order to be compliant with the new act. A number of changes have already been made such as adopting new Whistleblower and Conflict of Interest policies. The final step is to modernize AAPT's Constitution and By-Laws and recast these into By-Laws. This session will describe changes to the By-Laws and outline the vote that will take place this fall during the general election.

APS Plenary

Location: SSU - Hoff Theater
Date: Monday, July 27
Time: 7:30–8:30 p.m.

Presider: Janelle M. Bailey



S. James Gates, Jr.

Is SUSY the Guardian of Our Reality from Oblivion?

S. James Gates, Jr., Distinguished University Professor, University Regents Professor and John H. Toll Professor of Physics, University of Maryland

Our universe is apparently a place whose existence appears to be supported by finely wrought balances. For example, the size of the charge on an electron in contrast to its mass determines the size of atoms. If either quantity were substantially different from their observed values, the laws of chemistry could be changed so that biological processes could not occur. There are other measured quantities in Nature which could make even more dramatic differences. If the ratio of the mass of the recently discovered Higgs Boson to the so-called top quark were substantially different, the laws of physics could be changed in such a way that quantum fluctuations imply an instability in the very existence of our universe. One proposed aspect of Nature called "supersymmetry" seems to provide a way to avoid this fate and it is discussed in this presentation.

Co-sponsored by the American Physical Society Forum on Education and the Division of Particles and Fields

AAPT Poster Sessions

with Refreshments

Poster Session 1

8:30–10 p.m.
Monday, July 27
SSU - Colony Ballroom

Poster Session 2

5–6:30 p.m.
Tuesday, July 28
SSU - Colony Ballroom

Post Deadline Posters

1–2:20 p.m.
Wednesday, July 29
SSU - Grand Ballroom Lounge

PST1: Poster Session

Location: SSU - Colony Ballroom
Date: Monday, July 27
Time: 8:30–10 p.m.

Odd number poster authors should be present 8:30-9:15 p.m. Even number poster authors should be present 9:15-10 p.m. (Posters should be set up by 9 a.m. Monday and then taken down by 10 p.m. Monday)

A – Teacher Training/Enhancement

PST1A01: 8:30-9:15 p.m. ATE Workshop for Physics Faculty

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

Dwain M. Desbien, Estrella Mountain Community College

The ATE Workshop for Physics Faculty project is into its fifth year and has finished its 23rd workshop/conference. In this poster, we will display information about the project, information about these workshops/conferences, and information about future workshops/conferences. Information concerning development of laboratory activities will also be displayed.

PST1A02: 9:15-10 p.m. Beyond Content and Pedagogy: Challenges of the H.S. Physics Teacher

Poster – Bradley F. Gearhart, Buffalo Public Schools, 1982 Stony Point Rd., Grand Island, NY 14072; fizz6guy@yahoo.com

Teacher preparation programs are charged with providing pre-service physics teachers solid conceptual and pedagogical foundations to draw upon in their classroom instruction. However, in an authentic setting, content and pedagogy are but two strands in the thread of teaching as a profession. Navigating teacher evaluation systems, state standards, diverse student populations, building politics, logistical details, and various other facets of the profession are essential to maintaining a lasting career in teaching. My experience has shown that these are often overlooked aspects that are largely left "as an exercise for the reader." Drawing upon my experience as a physics teacher at a private catholic, a public suburban, and a public urban high school, I attempt to outline the responsibilities and concerns of the high school physics teacher while offering some perspective on the preparation of these teachers for the purpose of obtaining, and maintaining, a career in the profession.

PST1A03: 8:30-9:15 p.m. Enhancing Diversity in Physics Teacher Preparation Through the Georgia State University PhysTEC Project

Poster – Brian D. Thoms, Georgia State University, 25 Park Place, Room 605, Atlanta, GA 30303; bthoms@gsu.edu

Joshua S. Von Korff, Sumith Doluweera, Georgia State University

As a PhysTEC comprehensive site in the second year of a three-year grant, the Georgia State University team is working to develop an effective model of physics teacher recruitment and development at a diverse, urban research university. One of our goals is to prepare and support more physics teachers from under-represented minority groups. In addition to creating a well-qualified physics teacher work force in the Atlanta area, this also creates role models and mentors for a diverse high school student population to inspire them toward careers in science and engineering (and maybe even physics teaching). Recent efforts to build a thriving physics program with increased minority student success have established the foundation for producing a more diverse physics teacher force. Our PhysTEC project attempts to use our teacher-in-residence, learning assistants, and recruiting to bring more and more diverse students into physics teaching.

PST1A04: 9:15-10 p.m. Future Faculty Training at Yale: The Scientific Teaching Fellows Program

Poster – Rona Ramos, Yale University, Department of Physics, 217 Prospect St., New Haven, CT 0652;0 rona.ramos@yale.edu

Jennifer Frederick, Yale University, Center for Teaching and Learning

The Yale Scientific Teaching Fellows Program is a semester long, future faculty training course for postdoctoral researchers and graduate students in the sciences. The course covers learning theory, backward design, evidence-based teaching methods, and creating an inclusive classroom. As a final project, fellows develop teaching materials and implement them in our classroom. Analysis of pre- and post-teaching statements, surveys, and final teaching projects showing the evolution of the fellows' teaching philosophy will be presented. The shift in the fellows' viewpoint from teacher-centered to learner-centered will be highlighted, as well as recent efforts to make the diversity training component more effective.

PST1A05: 8:30-9:15 p.m. Involving Multiple Communities in the Preparation of Future Urban Science Teachers*

Poster – Mel S. Sabella, Chicago State University, Department of Chemistry and Physics, 9501 S. King Dr., SCI 309 Chicago, IL 60628 msabella@csu.edu

Tasha Williams, Ashley Furnace, Louis Isaac, Mike Tyler, Angela Moore, Jennifer Jacobs, John Brown, Karel A. Jacobs, Andrea Gay Van Duzor, Rita Koziarski, Chicago State University

Involving multiple communities in the preparation of future science teachers builds on local resources and prepares our preservice teachers to tackle diverse teaching settings. In this poster we describe three activities that connect CSU students to elementary school students (Noyce), high school teachers and their students (PhysTEC) and the community on the southside of Chicago. To introduce prospective preservice teachers to the profession, the PhysTEC Program helps students make an informed decision about whether teaching is right for them by placing them in the instructor role in a high school classroom for a single lesson that they design. CSU students who have committed to pursuing science teaching applied their knowledge of inquiry-based instruction to a teaching session with elementary school children and engaged in an engineering design activity using the context of the CSU Aquaponics Facility.

*Supported by the NSF (Grant 0833251) and the American Physical Society (PhysTEC)

PST1A06: 9:15-10 p.m. New Faculty Experience for Two Year Colleges: Program Update

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

Scott F. Schultz, Delta College

The New Faculty Experience for Two Year Colleges (NFE-TYC) recently finished another cycle of the AAPT/NSF sponsored professional development program and will soon begin to accept applicants for the next cohort of participants. This poster presents an update of the intensive four-day immersion conference, the commencement conference and the creation of a network of new two year college physics professionals who are developing additional roles within their teaching profession. Additional projects that are an outgrowth of this grant include two different "Leadership Conferences" for Two Year College Physics teachers and the organization of a TYC-Tandem meeting held at the AAPT Summer National Meeting. These project extensions will also be reviewed. For more information about the TYC-NFE contact: Scott Schultz , sfschult@delta.edu or Todd Leif, tleif@cloud.edu

PST1A07: 8:30-9:15 p.m. Novice Teacher Sense-Making About Responsive Teaching: Important Points in the Development of Language and Practice*

Poster – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave. W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu

Jennifer Richards, University of Washington

Documented efforts to support novice teachers in the practices of attending and responding to student thinking have noted that novices are capable of engaging in responsive teaching and have described methods for supporting the development of responsive teaching practices. However, few of these efforts have attended to the experiences of novices as they learn to be responsive, including the tensions and questions that arise for them. This case study analyzes the experiences of one cohort of novice physics teachers as they explore responsive teaching over the course of two academic quarters. Their experiences crystallized around several recurrent and central points of sense-making, including, for example, questioning whether or not it is okay to leave students with "wrong" answers and wondering whether their content knowledge is sufficient for responsive teaching. In highlighting these points of sense-making, we illustrate where this cohort of novice teachers is coming from, at multiple points during their engagement with responsive teaching for the first time. We aim to foster teacher educators' attention to novice teachers' own questions and tensions, in addition to novices' development of specific responsive practices.

*This material is based upon work supported by the National Science Foundation under Grant No. 122732.

PST1A09: 8:30-9:15 p.m. The Value of Khan Academy in Pre-service Science Teacher Education

Poster – Christine Lindstrom, Oslo and Akershus University College, Pilestredet 52 Oslo, Oslo NO-0130, Norway; christine.lindstrom@hioa.no

Khan Academy (KA) is a free online learning tool for a range of subjects. The mathematics module is particularly well developed and covers topics ranging from counting to first-year university mathematics. In fall 2014, KA was integrated into the introductory physics course for 24 pre-service science teachers at the largest teacher education institution in Norway, where many students struggle with basic mathematics. Students were encouraged to complete four relevant mathematics topics prior to each of seven physics classes. Throughout the semester, students spent on average 12 hrs 22 mins (SD = 6 hrs 1 min; N = 22) on KA, and showed a statistically significant improvement of 5.2 marks of 52 on a test of relevant mathematics knowledge (N = 20). The "coach" feature in KA enabled the instructor to monitor student problem solving speed and accuracy, providing a realistic overview of the students' actual mathematics knowledge.

B – Technologies

PST1B01: 8:30-9:15 p.m. Arkanoid

Poster – Theodore R. Halnon, The Pennsylvania State University 111 Kern Building, University Park, PA 16802; trh5241@psu.edu

Mikhail Kagan, The Pennsylvania State University, Abington College

This joint physics and robotics project was inspired by both the Smart Trash Can and the classic video game "Arkanoid", in which the user needs to control a moving paddle in order to control the bounce of a ball in a desired direction. The goal of the project was to model how the trajectory of a ball is manipulated when it bounces off of a moving paddle and then to build a working model based on realistic physical parameters. We did experimental analysis to determine the optimal materials for a working model. The parts of the design were then interfaced with an Arduino microprocessor and accompanying circuit in order to be electronically manipulated. We were successful in modeling the trajectory of a ball bounced off a moving paddle given easily measureable/controllable physical parameters. However, we were not able to get a working model of a life sized Arkanoid.

PST1B02: 9:15-10 p.m. MinecraftEDU Modeling Physics Labs

Poster – Natasha Collova, Siena College, 515 Loudon Rd., Loudonville, NY 12211; mmccolgan@siena.edu

Michele McColgan, Siena College

Worlds in MinecraftEDU are presented that represent modeling physics labs. Worlds include activities to help students to understand the models of constant velocity, constant acceleration, vectors, and energy.

PST1B03: 8:30-9:15 p.m. Computation in a Modern Physics Course: Homework, Laboratories, and Exams*

Poster – Marie Lopez Del Puerto, 2115 Summit Ave., St. Paul, MN 55105; mlpuerto@stthomas.edu

There is a need to develop materials that introduce students to computational physics with problems that are meaningful and challenging, yet are neither overwhelming to the students nor take substantial time from the more traditional theoretical and experimental components of a course. We have been working on a project to introduce computational physics in the undergraduate curriculum by blending computation and experimentation in the Modern Physics course and laboratory with materials that discuss contemporary physics subjects (statistical mechanics, quantum dots, LASERs, superconductivity, etc). In this poster we will describe how computation has been embedded in homework problems, laboratories and exams for this course. We will also give interested faculty information on how to obtain these materials.

*Laboratory and curriculum development for this "Applications of Modern Physics" course has been supported by the physics department and a grant from the Faculty Development Center at the University of St. Thomas, as well as NSF-TUES grant DUE-1140034, and MathWorks software and curriculum development grants.

PST1B04: 9:15-10 p.m. Status Update on C3PO: Customizable Computer Coaches for Physics Online*

Poster – Jie Yang, University of Minnesota, 116 Church St. SE, Minneapolis, MN 55455-0213; yang1999@umn.edu

Evan Frodermann, Ken Heller, Leon Hsu, University of Minnesota

Bijaya Aryal, University of Minnesota-Rochester

The University of Minnesota Physics Education Research Group has for a number of years been developing Customizable Computer Coaches for Physics Online (C3PO), a web-based system designed to provide students with coaching to improve their problem-solving skills. This poster describes the current status of the project, including the design process and the types of problems and instructor customizations that are supported by the system. The poster session also includes an opportunity to work with a prototype of the system.

*This work was partially supported by NSF DUE-0715615 and DUE-1226197.

PST1B05: 8:30-9:15 p.m. Turn Your Mobile Device into a Science Lab Space

Poster – Rebecca E. Vieyra, Triangle Coalition for STEM Education - Albert Einstein Fellowship, 225 C St. SE, Apt. B, Washington, DC 20003; rebecca.elizabeth.vieyra@gmail.com

Learn to collect, export, and analyze data using your Android device. A few mobile devices will be available for you to play with during the poster session. Some opportunities for interaction at the poster session will include: Accelerometer - Determine acceleration due to gravity, estimate force during a jump; Magnetometer - Measure changes in magnetic field as a speaker produces sound; Light Sensor - Investigate how angle of incidence from sunlight causes the seasons; Tone Generator - Generate beats or cancel out sound; Sound Meter - Measure the changes in sound intensity as a speaker produces sound; Proximeter - Measure the period of a pendulum; Physics Toolbox Wear - Try on a smart watch to measure your motion; Hygrometer - Measure the relative humidity of the room or puff of your breath; Orientation – Use as an inclinometer.

PST1B06: 9:15-10 p.m. Undergraduate Self Directed Entrepreneurial Research and Outreach Projects: 3D Printing

Poster – C. Dianne Phillips, NorthWest Arkansas Community College, One College Dr., Bentonville, AR 72712; dphillips@nwacc.edu*

Lee Stidham, Nathan Sorey,* NorthWest Arkansas Community College*

Undergraduate students from STEM courses are self-directed as they create their own innovative learning environment; use experimental project design and high-end computer technologies to create their own entrepreneurial learning experiences. Teams of highly motivated students work individually and collaboratively to develop new technologies and applications which combine GIS, 3D Graphic Design, and 3D Printing. They design and conduct K-12 workshops to teach innovative technologies. In addition they also train college level faculty, staff, and fellow students. Independent Study and Research students gain valuable professional experience as they learn to research and design projects as well as write funding proposals

*Sponsored by C. Dianne Phillips

PST1B07: 8:30-9:15 p.m. Using Interactive Whiteboards to Support Student Investigation and Communication

Poster – Bor Gregorcic, University of Ljubljana, Jadranska 19, Ljubljana, 1000 Slovenia; bor.gregorcic@fmf.uni-lj.si

Eugenia Etkina, Rutgers University

Gorazd Planinsic, University of Ljubljana

Interactive whiteboards (IWBs) have become a common piece of equipment in classrooms all over the world. In many cases, teachers continue to use them in teacher-centered lessons. We will present examples of how learners can use the interactive whiteboard to investigate new physics and communicate their ideas to each other in the process of scientific inquiry. The IWB's kinesthetic and graphical potential both play an important role in these instructional activities.

PST1B08: 9:15-10 p.m. Using Learning Catalytics in an Introductory Physics Course to Non-majors

Poster – James D. Rall, Northern Arizona University, 948 W Coy, Flagstaff, AZ 86005; james.rall@nau.edu

The use of clickers as a student response system is widely used and accepted throughout Northern Arizona University. Using clickers can have a limiting way of assessing the student's true knowledge. As such, I have implemented the use of Pearson's Learning Catalytics in my College Physics course for non-majors. I use a number of different question types including sketches, highlighting, equation submission, numerical with units, drawing arrows, etc. Learning Catalytics gave me a method not only to assess student learning, but to evaluate and improve on different methods of teaching. Examples of this and others will be presented along with goals for expanding this technology in the classroom.

PST1B10: 9:15-10 p.m. Video Supplements in Physics Courses at Colorado School of Mines

Poster – Todd Ruskell, Colorado School of Mines, Physics Department, 1523 Illinois St., Golden, CO 80401; truskell@mines.edu

Alex Flournoy, Mark Lusk, Patrick Kohl, Eric Toberer, Colorado School of Mines

At Colorado School of Mines we have developed online video materials for several courses in our Physics curriculum. In our Physics I course, we created video lectures for each topic to model problem solving. In our majors courses of Intermediate Mechanics and Advanced Electricity and Magnetism, pre-course videos are an essential component of the flipped classroom model. In mechanics, most these videos take the form of "pre-written" lecture notes, revealed and narrated in chunks. In E&M, the notes are written and narrated synchronously, with written notes often accelerated from their real-time pace. Video lectures in our senior-level elective Solid State Physics course take the form of scripted student-faculty dialogues, also in support of a flipped classroom. We discuss the differences in pedagogy for the videos in each course, the production tools used, the workflow for producing our videos, and the time commitment required by those looking to develop similar resources.

PST1B11: 8:30-9:15 p.m. With Physics to Everywhere: Experiments Using Your Smartphone

Poster – Arturo C. Marti, Physics Institute, Universidad de la República, Iguá 4225 Montevideo, Montevideo 11400 Uruguay; marti@fisica.edu.uy

Cecilia Stari, Cecilia Cabeza, Physics Institute, Universidad de la República

Martín Monteiro, Universidad ORT Uruguay

Smartphone usage has expanded dramatically in recent years. According to press releases one billion smartphones were sold in 2013 worldwide. The use of smartphones goes considerably beyond the original purpose of talking on the phone. Indeed, it is everyday more frequent to use smartphones as clocks, cameras, agendas, music players or gps. More remarkable is the habit, especially among young people, of bringing their smartphones every time and everywhere. From a physicist's point of view, it is impressive that smartphones usually incorporate several sensors, including accelerometers, gyroscopes, and magnetometers. Although these sensors are not supplied with educational intentions in mind, they can be employed in a wide range of physical experiments, especially in high school or undergraduate laboratories. Moreover, experiments with smartphones can be easily performed in non-traditional places as playgrounds, gyms, travel facilities, among many others. All the possibilities that smartphones exhibit, foster students interest in exploring, measuring and meeting the physical world around them.

C – Other

PST1C01: 8:30-9:15 p.m. A Continuing List of Climate Myths

Poster – Gordon J. Aubrecht, Ohio State University at Marion, 1465 Mt. Vernon Ave., Marion, OH 43302-5695; aubrecht.1@osu.edu

This continues the series of posters on climate myths.

PST1C02: 9:15-10 p.m. Modern Physics for General Education Students: Teaching "Claims, Evidence, Reasoning"

Poster – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099; pawla@uwplatt.edu

One of the most important goals of a general education science course is to teach students what it means to provide quantitative and/or experimentally-grounded evidence for a claim and how to explain the reasoning that links the evidence to the claim. The historical development of the three pillars of Modern Physics (kinetic theory, relativity, and quantum theory) provides a perfect context for teaching the Claims, Evidence, Reasoning framework of argumentation and at the same time supplies a motivation for introducing students to several core models of classical physics (particles, momentum, kinetic energy, electric energy and waves). In this presentation I describe an experimentally-grounded introduction to Modern Physics for a general education audience that was offered at the University of Wisconsin-Platteville for the first time in spring 2015. Laboratories, reading assignments, homework and exams all employed the Claims, Evidence, Reasoning framework in varying degrees. Course materials are available upon request.

PST1C03: 8:30-9:15 p.m. SSEP: District Wide STEM Competition Mimics How Science Is Done

Poster – James Flakker, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08903; jim.flakker@gse.rutgers.edu

Eugenia Etkina, Rutgers University

With the help of the National Center for Earth and Space Science Education (and others), we secured a mini-lab and transportation to and from the International Space Station. Then Berkeley Heights Publics Schools implemented a Science Experiment Design Competition to mimic how scientists compete for grants and the ability to carry out their experiment. Starting with a "Call for Proposals" for students grade 6-12 in our district to design an experiment that can test a physical, biological or chemical system in an environment seemingly without gravity. With over 1000 students participating, the winning experiment was selected and flew to ISS for six weeks this past winter.

PST1C04: 9:15-10 p.m. Providing Feedback During an Exam to Enhance Learning

Poster – Carl Schmiedekamp, The Pennsylvania State University, Abington College, 1600 Woodland Rd,. Abington, PA 19001; cws2@psu.edu

Studies have shown that students can learn during an exam if there are immediate feedback and iterative responding to the exam questions. Since the students in my classes were already using the WebAssign online homework system, I investigated using WebAssign for proctored, online exams. These techniques extend the immediate feedback and iterative responding to questions with numerical answers in addition to the usual multiple choice questions used in this way. Details of the scoring algorithms and preliminary results of using these techniques in an algebra based introductory physics course will be presented.

PST1C05: 8:30-9:15 p.m. Longitudinal Flow of Student Test Scores at the Campus Level

Poster – Matthew W. Guthrie, The University of Texas at Austin, Department of Physics, 2515 Speedway, C1600 Austin, TX 78712; mwguthrie@physics.utexas.edu

Michael Marder, The University of Texas at Austin

From 2003 to 2011, every student in the Texas public school system from third to 11th grade took the Texas Assessment of Knowledge and Skills (TAKS). We analyze the student scores for the mathematics portion of this test using a nonlinear, nonparametric model inspired by fluid mechanics for the study of semi-deterministic data. This model has been used to highlight characteristics in the TAKS data set that might not be observed using other analytic techniques. For example, one previous analysis of TAKS using our model showed that a statewide initiative caused statistically significant gains in test scores for affected students. If we observed this effect at the state level, can we observe similar effects at the campus level? This poster will detail the extension of our model to campus level data, in particular by analyzing schools with similar demographics but differing pedagogical methods.

PST1C06: 9:15-10 p.m. Assessing Student-led Discussions About Underrepresented Groups in STEM

Poster – Libby K. Booton, Colorado School of Mines, 1523 Illinois St., Golden, CO 80401-1843; lbooton@mymail.mines.edu

Alex T. Flournoy, Kristine E. Callan, Colorado School of Mines

Equality Through Awareness (ETA) is a growing student club at the Colorado School of Mines. ETA's mission is to spread awareness and support for issues faced by underrepresented groups in STEM fields. In addition, ETA serves as an affinity group for the women in physics at Mines. One of the main components of ETA is a weekly meeting where students discuss an article related to underrepresented groups in STEM. Over the course of a semester, attendance has been monitored and the participants have been timed during the discussions to help the organizers better understand the participation dynamics of the group. This poster will explore the participation of men in a group focused on women and other underrepresented groups in STEM, and it will also explore how group dynamics are impacted when the role of the discussion leader is rotated each week.

PST1C07: 8:30-9:15 p.m. I-PERSIST: Combining STEM Course and Student Life Mentoring at a Technical University*

Poster – Peter D. Persans, Rensselaer, Polytechnic Institute, 110 Eighth St.,Troy, NY 12180-3590; persap@rpi.edu

Wilfredo Colon, Janelle P. Fayette, Lisa Trahan, Bruce Piper, Rensselaer Polytechnic Institute

I-PERSIST is a peer mentoring program in which disciplinary mentoring is integrated with student life and counseling in the first semester of calculus, physics, and chemistry at Rensselaer Polytechnic Institute. Rensselaer is a technological university at which over 80% of the degrees granted are in STEM fields. Approximately 32% of the first year class in fall 2014 were female and 14% were underrepresented minorities. Rensselaer strives to increase these fractions and improve degree completion rates. I-PERSIST provides a supportive environment for all students, but a major goal is to improve the success of STEM under-represented groups. The disciplinary portion of I-PERSIST is fully integrated into each introductory course and usually has a percentage of the course grade associated with it. We will discuss the structure of the mentoring portion of our courses, recruiting and training peer mentors, and outcomes of mentoring for both mentees and mentors.

*Supported in part by a grant from the Howard Hughes Medical Institute.

PST1C08: 9:15-10 p.m. How Can Lesson Study Promote Active Learning in College Physics?

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

University faculty members are often isolated in terms of discussing teaching strategies that are effective for helping students overcome difficulties in understanding the concepts they present. This study examines how a collaborative lesson planning and discussion scheme called Lesson Study can provide faculty in physics with a vehicle to discuss teaching in a content specific way. A symposium on Lesson Study and active learning was held in a college. Faculty's attitudes towards collaboration and active learning strategies were measured by pre/post-program survey (N=32). The preliminary results indicate that the participants of the symposium feel more comfortable asking their colleagues questions about their teaching. The results also indicate that Lesson Study helps faculty see teaching in a more student-centered way. The effect of a content-rich discussion in the Lesson Study process will be further analyzed as a key factor for making the college-level Lesson Study sustainable.

PST1C09: 8:30-9:15 p.m. Sweet Experiments in Physics and Optics with Candy Glass

Poster – William R. Heffner, Lehigh University, 478 Rebers Bridge Rd., Sinking Springs, PA 19608; wrh304@lehigh.edu

Himanshu Jain, Lehigh University

We present a collection of hands-on experiments and home-built apparatus designed to explore physics and "real" glass science through a common and accessible sugar glass also known as hard candy. Experiments are all low-cost and inter-related and include: synthesis, phase diagram, refractive index measurement, nano-carbon fluorescence and crystallization phenomena, as well as apparatus for differential thermal analysis, electrical conductivity and "optical fiber" drawing. Most of the experiments can be assembled in a high school or college lab with minimal cost. The scientific content of these experiments progresses systematically, providing an environment to develop an understanding of glassy materials and participate in the process of scientific inquiry and discovery through experimentation, within a framework of active prolonged engagement.

PST1C10: 9:15-10 p.m. Infared Imaging: Learning Physics from Cultural-Heritage Diagnostics

Poster – Peppino Sapia, University of Calabria, DiBEST UNICAL- Ponte Bucci, cubo 4B Rende 87036, CS 87036 Italy; peppino.sapia@unical.it

Assunta Bonanno, Fabio Stranges, University of Calabria

Imaging techniques based on the interaction of electromagnetic radiation with matter play a key role in different fields, ranging from medical diagnostics to the diagnostics applied to the protection and promotion of cultural heritage. In the last case, Infrared Reflectography (IRR) constitutes a very useful investigation technique that allows non-destructively exploring the details underlying a painting or a pottery's decoration. With a modified commercial digital camera and a bit of expertise, you can make an inexpensive device that can perform simple IRR, providing useful teaching suggestions for the discussion of the qualitative aspects of the interaction of radiation with matter. In this work, we present a sequence of didactical experiments performed with our home-modified camera - well suited for pre-college students -- aimed both to promote the qualitative learning of the radiation-matter interaction and the outreach of physics applications to fields of interest traditionally perceived as very distant from the empirical sciences.

PST1C11: 8:30-9:15 p.m. Physics Principles in the Bathroom

Poster – Russell A. Poch, Howard Community College, 10901 Little Patuxent Pkwy., Columbia, MD 21044-3197; RPOCH@howardcc.edu

Have you ever wondered how a roll of toilet paper can be useful for illustrating basic physics principles? The answer to this question and other non-censored physics principles displayed in the bathroom will be illustrated.

PST1C12: 9:15-10 p.m. Crafting Ray-Tracing Problems with Parabolic Reflectors Beyond the Paraxial Approximation

Poster – Richard Zajac, Kansas State University, Salina, 2310 Centennial Rd., Salina, KS 67401; rzajac@ksu.edu

The pedagogical goals of geometrical ray-tracing with curved reflectors can be undermined by students' numerical-only use of the mirror equation, especially in online environments where graphical work seldom gets submitted. We strategically generate ray-tracing problems involving large objects/images with true-parabolic reflectors for which the mirror equation's paraxial approximation fails dramatically, making graphing strategies the least prohibitive means of obtaining a correct answer. The related problem space is mapped and useful areas of convergence are identified. We find that a strategic choice of parameters allows problems to be crafted for which a numerical submission alone is sufficient to verify the student's correct application of graphical-only methods rather than numerical substitution into a formula. Such a purely numerical submission is ideally suited to online homework. The visible failure of the mirror equation in these problems is shown to impact students' appreciation of the paraxial model under girding the mirror equation.

PST1C13: 8:30-9:15 p.m. Novel Physics Demonstrations for Easy Learning

Poster – Ravin Kodikara, Webster University, 470 East Lockwood Ave., St. Louis, MO 63119; ravinkodikara30@webster.edu

Nickolas Rau, Webster University

Physics is an interdisciplinary science providing an important framework to better understand the complexities of many disciplines in science and technology. Comprehending and applying the basic principles of physics is therefore paramount to success in any science-related field. However, many students even at the collegiate level struggle to grasp seemingly undemanding physics-based concepts (author's observations). For an example, the simple idea of "equilibrium of forces" explained using force diagrams could be a challenge for many students. This project describes several demonstrations developed to make physics concepts more accessible and understandable to students. These presentations will help students get an actual "feeling" of the concepts while encouraging them to investigate the ideas further. The setups are designed to be thought provoking thereby providing a platform for follow-up discussions. Additionally and most importantly, certain demonstrations have a combination of multiple theories and concepts to reveal cross-relationships among different fields and to promote inquiry.

D – Labs/Apparatus

PST1D01: 8:30-9:15 p.m. Non-Linear Oscillation of a Physical Pendulum

Poster – Brian Swain, Santa Rosa Junior College, 4824 Grange Rd., Santa Rosa, CA 95404; bswain47@hotmail.com

Peter Chanseyha, Santa Rosa Junior College

A mathematical model was developed to predict the non-linear oscillation of a physical pendulum. The model was tested against experimental data obtained by using a water filled, long, cylindrical tube and allowing water to escape from the bottom of the tube while it was set into oscillation. After empirically determining the exponential decay of the oscillation amplitude, the theory was found to be in good agreement with the experimental data. As the first approximation, the exponential decay was assumed to be constant as well as the velocity of the water exiting the tube. To achieve better agreement between the experimental data and the model, it was necessary to take into account the variation of the water velocity.

PST1D02: 9:15-10 p.m. Sound Lab Suitable for Hearing Impaired Students

Poster – Gregory L. Dolise, Harrisburg Area Community College, 1 HACC Dr., B232F Harrisburg, PA 17110; gldolise@hacc.edu

This shows the methods and results of a physics lab suitable for students who are hearing impaired. Using relatively inexpensive electronic sound sensors, tuning forks, and sound sensors, a visual representation of sound intensity is produced. Modifying a pair of matched tuning forks with a simple rubber band produces beats at different frequencies. Beats can be clearly seen and beat frequency calculated using produced graphs even if the sound cannot be heard. This lab has been used successfully with all students in an introductory physics class, generating a great deal of enthusiasm.

PST1D03: 8:30-9:15 p.m. Speed of Sound in Coca Cola Products

Poster – Bob Powell, University of West Georgia, Department of Physics, Carrollton, GA 30118; bpowell@westga.edu

Daniel Hartman, Benjamin Jenkins, University of West Georgia

The speed of sound in Coca Cola products (Classic Coca Cola, Diet Coca Cola, and Coca Cola Zero) has been measured using the Speed of Sound apparatus manufactured by Iowa Doppler. This study also involved freshly opened beverages with carbonation and "flat" or un-carbonated beverages at intervals of a day and a week after being opened to determine the effect of carbonation on the speed of sound. Classic Coca Cola had a speed of sound higher than both Diet Coca Cola and Coca Cola Zero; the speed of sound in the last two beverages was close to that of distilled water. In the Classic drink, there was little change in the speed of sound between the newly opened and the "flat" variety, but there were minor changes in the Diet and Zero flavor drinks depending on the amount of carbonation present.

PST1D04: 9:15-10 p.m. The Development of a Suite of Physics Laboratory Activities for Life Science Students*

Poster – Elliot E. Mylott, Portland State University, 2305 SE Yamhill, Portland, OR 97214; emylott@pdx.edu

Justin C. Dunlap, Ellynne Kutschera, Grace Van Ness, Ralf Widenhorn, Portland State University

Portland State University has been developing courseware for introductory and intermediate level Physics for the Life Sciences that strengthen the connection students make between physics and medicine. As part of these courses, we have created a number of laboratory activities that explore the fundamental physics behind ubiquitous medical devices. Topics explored in the activities include planar x-ray imaging, Computed Tomography, Pulse Oximetry, electrocardiogram, and Bioelectrical Impedance Analysis. These activities feature original hardware and software, all of which are designed for easy adoption by other educational institutions. The materials have been assessed and refined over several iterations of an intermediate-level biomedical physics course and some have been adapted for the introductory physics lab for life science students. Together they offer students a dynamic, hands-on approach to exploring the relevance of physics to medicine.

*This work was supported by grants (DUE-1141078 and DUE-1431447) from the National Science Foundation.

PST1D05: 8:30-9:15 p.m. The Smart Mass

Poster – Scott Dudley, TASIS, Coldharbour Lane, Thorpe, TW208TE, United Kingdom; sdudley@tasisengland.org

Francesco Insulla, Sidney Mau, TASIS

In this poster we'll present results from using accelerometers in devices such as tablets and smartphone to measure systems which are typically measured with video analysis. We allow the device itself to be the accelerating mass—which we call a "smart mass"—in systems such as Atwood's machine or moment of inertia measurements.

PST1D06: 9:15-10 p.m. Three Aspects of Teamwork that Are Critical to Learning Physics

Poster – Karen A. Williams, East Central University, 1020 E. 6th Ada, OK 74820; kwillims@mac.com

Teamwork is a skill that students must learn in this day and age of computers, Internet, and texting that isolates us all from other humans. I have seen three aspects of teamwork that are critical to student success in my courses. First students appear to learn better if they have someone to study with, interact with, and teach what they know to. Secondly they must have teamwork in the laboratory setting. For one not many of us have enough equipment for each student to do it alone. Secondly it is difficult to take data alone in some experiments plus the learning from others is absent. Students must have experience working with a variety of individuals in lab in this world of texting instead of communicating verbally. I also believe that students must have experience as a team working on part of a project while other teams work on other aspects of the same project. I call this the "NASA type" of real-world teamwork. I contend that teamwork is a laboratory skill that must be learned. This is not extensive research on teamwork, but I have taken assessment data for a year on our students teamwork skill in Jr Physics lab. I will discuss the situations in which different aspects of teamwork can be simulated in the lab and the instrument that we use to assess teamwork skill. I will also discuss student reactions to being forced to work with others and with other teams.

PST1D07: 8:30-9:15 p.m. Undergraduate Biophysics Laboratories for AFM

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

Biotechnology and medical engineering are promising areas for the next generation of physicists to make an impact. However, we must prepare our students for these opportunities. Here we describe several biophysical experiments that could be done in the undergraduate teaching laboratory using an AFM. In each laboratory, we image a biological material and quantify a biophysical parameter: 1) imaging cells to determine membrane tension, 2) imaging microtubules to determine their persistence length, 3) imaging the random walk of DNA molecules to determine their contour length, and 4) imaging stretched DNA molecules to measure the tensional force.

PST1D08: 9:15-10 p.m. Using Batman and Other Shapes to Help Understand Circuit Elements

Poster – Matt Olmstead, King's College, 133 North River St., Wilkes Barre, PA 18711; matthewolmstead@kings.edu

One important function of an electronics lab is to learn, and gain hands-on knowledge, of the limitations of the theoretical devices covered in lecture. When a group of students saw the outline of Batman on their oscilloscope, the other students wanted to see. Although the circuit was built incorrectly, it became a great opportunity to both diagnose how the circuit was incorrectly connected and learn more about the elements in the circuit, in this case an operational amplifier. As a result of seeing Batman, the students have thought about what other shapes they can make when new circuit elements are introduced. With the recent introduction of a capacitor and an integrating amplifier, the students immediately began discussing how they could use these to make other patterns. Shapes have caused the students to take a strong interest in the analysis of their circuits, both theoretically and on the oscilloscope.

PST1D09: 8:30-9:15 p.m. Using Kinematic Equations to Design and Control Linear Motions*

Poster – Frederick J. Thomas, Math Machines, 1014 Merrywod Dr., Englewood, OH 45322; fred.thomas@mathmachines.net

A simple-to-construct motorized cart can move in response to functions entered in forms such as "x = x0 + v0*t + .5*a*t^2", "v = v0 + a*t", "x = 200*sin(pi(2)*t/10)" and more. Classroom uses include an algebra-driven extension to kinesthetic Graph Match activities with motion sensors. Other activities engage students in applying kinematic equations to engineering-style tasks, such as "Design a sequence of equations to make the cart carry an upright AA battery from one end of the track to the other as quickly as possible without the battery falling over." Building instructions, software, and classroom activities will be available.

*Supported in part by NSF's Advanced Technological Education Program through grant DUE-1003381. More information is available at www.mathmachines.net.

PST1D10: 9:15-10 p.m. Visualization and Analysis of Joule Heating of Resistors

Poster – Soo-Jeong Baek, Seoul National University, Department of Physics Education, Seoul 151 748 South Korea; sj73735@snu.ac.kr

Dong-Ryul Jeon, Seoul National University

Visualization is an effective way of conveying physical concepts of invisible phenomena. One of the important and invisible phenomena is the heating of resistors in the electrical circuits. Since the heat is invisible, however, it is difficult to relate the formula to the actual power dissipation. To help students' understanding, we took thermal images of resistors while passing current through them. And we analyzed from the thermal images the temperature increase before reaching the equilibrium by using a heat dissipation theory including the conduction loss. Resistance depends on the length and cross section of the material. To demonstrate this, we cut an aluminum foil in various shapes to make resistance of different values. The thermal images taken from the aluminum foil resistors successfully revealed how the resistance is related to the shape of the material. Our work serves as an example of how visualization can draw students' interests into invisible phenomena and enhance their understanding of the underlying physics.

PST1D11: 8:30-9:15 p.m. VersaLab: A Measurement Cryostat and Teaching Curriculum for Advanced Labs

Poster – Neil Dilley, Quantum Design, Inc,. 6325 Lusk Blvd., San Diego, CA 92121; neil@qdusa.com

Stefano Spagna, Quantum Design, Inc.

Richard Averitt, University of California, San Diego

Stephen Tsui, California State University, San Marcos

The VersaLab Physical Properties Measurement System from Quantum Design provides a controlled temperature/field platform (50 K - 400 K / 3 tesla) which can host a variety of integrated measurements. These include DC and AC magnetometry, heat capacity, thermal transport and electronic transport, in addition to custom experiment possibilities. We have developed six experiment modules to enable instructors and students to quickly get under way with exciting modern physics experiments such as resistivity in YBCO and specific heat of the metal insulator phase transition in vanadium oxide. These modules build proficiency in synthesizing/mounting samples, using the VersaLab, and in scrutinizing the data produced. An important element of this curriculum is teaching about the inner workings of the VersaLab cryostat and measurements so that students understand instrument limitations. Being a well-established, state-of-the-art research platform, the VersaLab provides opportunities for students and teaching faculty to publish in leading research journals. Quantum Design has also launched a website dedicated to laboratory instruction where new experiments can be contributed, and where the physics instruction community can further collaborate on these experiments.

PST1D12: 9:15-10 p.m. A Powerful Spectrograph Based Upon a Low Cost Spectrograph

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

We have been using low-cost spectrographs (made of cardboard and DVD fragments) for a few years. In the process of our study, we decided to make a spectrograph using the same optical design but with quality optical parts. This new spectrograph was found to be easily aligned, very accurate (~ 0.2 Angstrom accuracy), and enables intermediate and advanced students to study molecular spectral lines. We will present theory of operation as well as accurate photographs of molecular spectra.

PST1D13: 8:30-9:15 p.m. AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum: An Overview

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

A subcommittee* of the AAPT Committee on Laboratories has produced the *AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum* document, which was endorsed by the AAPT Executive Board on November 10, 2014. This set of curriculum recommendations includes objectives, experiences, and learning outcomes for the introductory and advanced (i.e. beyond first year) labs that foster the development of many key 21st century skills and competencies. The recommendations are broadly written so that they can be implemented at any college or university. The recommendations generated by the subcommittee as well as some ideas on how to use this document will be presented.

*The other members of this subcommittee were Nancy Beverly, Duane Deardorff, Dick Dietz, Melissa Eblen-Zayas, Robert Hobbs, Heather Lewandowski, Steve Lindaas, Ann Reagan, Randy Tagg, Jeremiah Williams, and Benjamin Zwickl.

PST1D14: 9:15-10 pm. Dirt Cheap and Versatile Spectrographs

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

Mark Masters, Jacob Millspaw, IPFW

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, and a cheap camera (we usually use a $30 webcam but a phone with a camera will also work). Despite the inexpensive parts, the shoebox spectrograph can be remarkably accurate ("accurate" based upon the "quality" of the component parts) and versatile. One obvious experiment is to take spectral photos of light from different atomic sources (our wavelength measurements for a well-built spectrograph are accurate within a nanometer and we can resolve the Hg 576.96nm line from the Hg 579.07nm line). But our dirt cheap spectrograph can be used in many more applications than just this. We have used it to examine transmission of white light through dye tinted water. We can observe the Fraunhofer lines in sunlight. We have done reflection spectroscopy including dandelion flower reflection spectroscopy. We have also developed an experiment we call laser induced fluorescence of Play Doh. All of this is done at low cost (assuming one has access to computers).

PST1D15: 8:30-9:15 p.m. Do We Charge More Each Time We Open the Refrigerator?

Poster – Jiwon Seo, Seoul National University of Education, 96 Seocho-Joongang-ro, Seocho-gu, Seoul Seoul, 137-742 Korea, Republic of Korea; sjw0010@hanmail.net

Youngseok Jhun, Seoul National University of Education

There are a lot of common practices about the refrigerator: "When you open the door of the refrigerator, the power consumption increases." and "Do not fill the refrigerator full to save electricity" etc. However, we do not pay attention to whether it is true or not. In this study, the change of refrigerator's power consumption has been monitored in various circumstance: Frequent refrigerator door opening, Full-filled refrigerator and Empty refrigerator. As an experiment device, "Electrical Energy Meter" was used to measure the amount of electrical energy usage, and the measured data was sent to the computer for data processing and result display.

PST1D16: 9:15-10 p.m. Eavesdropping by Using the Laser Beam Reflection Off a Window

Poster – Eunhye Shin, Department of Physics Education, Seoul National University, Seoul 151-742 Seoul, 151 742 South Korea; ajfflskfwk33@naver.com

Dongryul Jeon, Department of Physics Education, Seoul National University

When someone speaks in a room, the sound pressure gives a stress to the window forcing the glass to bend accordingly. If one measures the vibration of the glass, one can reproduce the sound pressure. We used a laser beam and a photodiode to practice this well- known principle of eavesdropping. In order to find the optimal conditions of laser eavesdropping demonstration in the classroom, our first method was to measure the variation of the reflection angle of the laser beam incident from the window. Our second method was to measure the variation in the intensity of the laser light. We will share our experience in tuning the measurement conditions and discuss the results we obtained.

PST1D17: 8:30-9:15 p.m. Embedding Scientific Reasoning Instruction in the First Semester Introductory Laboratory*

Poster – Larry J. Bortner, University of Cincinnati, 400 Geology/Physics Bldg., PO Box 210011, Cincinnati, OH 45221-0011; bortnelj@ucmail.uc.edu

Kathleen Koenig, Carol Fabby, University of Cincinnati

College students with developed reasoning abilities have been shown to have enhanced chances at achievement in STEM classes. However, few courses specifically target scientific reasoning. In light of this, we changed our introductory lab course curriculum to include tailored instruction on these competencies. The classes are group-based inquiry labs where an instructor engages in Socratic dialog with a group at structured checkpoints. Four lab reports are required each semester and are scaffolded over several labs. Out-of-class assignments include readings that address these desired abilities which are then practiced and applied in hypothetical scenarios as well as during the actual in-class lab activities. Weekly online quizzes focus on the development of these skills and provide feedback to both student and instructor. Improvements in targeted areas of scientific reasoning by students in the revised labs are borne out by pre- and post-assessments and will be discussed during this presentation.

*Support provided by NSF DUE 1431908

PST1D18: 9:15-10 p.m. Experiment-based Test Problems

Poster – Scott Dudley, TASIS, Coldharbour Lane, Thorpe, TW208TE ,United Kingdom; sdudley@tasisengland.org

Francesco Insulla, Rachel Maerz, Sidney Mau, Shiyan Xu, TASIS

In this poster we'll analyze some data based experimental problems from standardized tests (AP for example) and compare to actual measurements of the same problem.

PST1D19: 8:30-9:15 p.m. Performance Test – Building a DC Circuit

Poster – Dan Liu, University of New Haven, 300 Boston Post Rd., West Haven, CT 06516-1999; DaLiu@newhaven.edu

The investigation of a performance test in physics—building a DC circuit is reported. The time for completing the test is a criterion to assess students' lab skills in this study. The problems found during implementing the test are discussed and the solutions are proposed, such as applying time criterion, gambled connecting cables.

PST1D20: 9:15-10 p.m. Towards Optimal Experience: Students' Attitudes in Design Labs

Poster – Anna F. Karelina, 42 Broadmoor Ct., San Ramon, CA 94583; anna.karelina@gmail.com

Students' frustration can be a crucial factor preventing successful implementation of inquiry-based techniques. Here we describe our results of improving students' attitudes towards open-ended ISLE labs where students have to design their own experiments. We apply the flow framework[1] for analysis of students' responses to the survey about their experience during the labs. We describe the revision of the course based on this analysis that resulted in a significant improvement of students' attitude toward the labs.

1. Csíkszentmihályi, Mihály (1990), *Flow: The Psychology of Optimal Experience,* New York: Harper and Row

PST1D21: 8:30-9:15 p.m. Trying to Keep the Intro Lab from Being Mind-numbingly Boring

Poster - Mark F. Masters, IPFW, 2101 Coliseum Blvd., E Fort Wayne, IN 46805; masters@ipfw.edu

Jacob Millspaw, IPFW

Often times introductory physics laboratories become incredibly tedious for the students and the instructor. Even though we have had very successful laboratories (as measured by student learning), we have felt that the labs do not excite students. Therefore, we wanted to develop a laboratory that would get the students much more engaged in physics and mirror scientific experience. Our hopes were that this would be less boring. This poster will describe our most recent introductory laboratory innovation and some of our measures of success (or failure).

PST1D22: 9:15-10 p.m. Using Laser Distance Sensors in the First Year Physics Labs

Poster – Daniel E. Beeker, Indiana University, 727 East 3rd St., Bloomington, IN 47405; debeeker@indiana.edu

Experiences and tips on using laser distance sensors in the first year physics labs are presented.

PST1D23: 8:30-9:15 p.m. Citizen Science: A Tool for an Introductory Science Curriculum

Poster – Carolin N. Cardamone, Wheelock College, 200 The Riverway, Boston, MA 02215; ccardamone@wheelock.edu

Citizen Science, collaborations between professional scientists and members of the wider community, provide a unique educational opportunity for introductory science courses. Allowing students to participate in Citizen Science projects and to develop their own research questions creates an environment in which students can come to understand science as a vital and living process rather than an abstract set of knowledge. In this poster, I will describe an introductory science course, whose cornerstone is a semester-long student-developed research project. Students begin by participating in Citizen Science projects to build the confidence, attitude, and skills necessary to begin their own research. Research projects then create a collaborative learning environment that brings students into the instruction, asking them to explain their developing understandings of science and work with their peers to understand new ideas. I will discuss how this technique can be applied across a variety of curricula from introductory to advanced courses.

E – Physics Education Research

PST1E01: 8:30-9:15 p.m. Characterizing Alternative Certification Candidates' Perceptions and Understandings of Physics Teaching

Poster – Kathleen Ann Falconer, SUNY Buffalo State College, 27 East Girard Blvd., Buffalo, NY 14217; falconka@buffalostate.edu

Joseph Zawicki, Dan MacIsaac, SUNY Buffalo State College

A reanalysis of the data from an earlier grounded theory study into alternative certification candidates' perceptions and understandings of physics teaching. Candidate beliefs and values about physics content and teaching are presented. Their views, perceptions, attitudes and beliefs about physics content and teaching were elicited through interviews with a variety of candidates from within the program, including new graduate students as well as recent graduates from the program. The alternative certification candidates' perceptions of the teacher's role in teaching physics and improving students' understanding of physics content were explored with better understanding of physics content, reformed teaching and egalitarianism emerging as major themes. Implications for future physics teacher will be addressed.

PST1E02: 9:15-10 p.m. Using Students Ideas of Conditionals and Bi-conditionals to Probe Conceptual Understanding

Poster – David Maloney, Indiana University Purdue University, Fort Wayne, 2101 East Coliseum Blvd., Fort Wayne, IN 46805; maloney@ipfw.edu

We provided students with a basic guide for conditional and bi-conditional statements and how to draw inferences from them. We then constructed a task format that required the students to determine the validity of a statement involving basic physics concepts, correct it if it was not valid, identify the statement as either conditional or bi-conditional, and then apply it to a physical situation. Students were then presented with a sequence of these tasks as homework assignments and test items. We report on the struggles the students had with two aspects of these tasks. First they had difficulty understanding the logical characteristics in the tasks, e.g. distinguishing conditionals from bi-conditionals and determining what could reasonably inferred from them. Second they had difficulty determining validity and type of statement that were about fundamental physics concepts.

PST1E03: 8:30-9:15 p.m. College Student Conceptions About Buoyancy and Density

Poster – DJ Wagner, Grove City College, 100 Campus Dr., Grove City, PA 16127; djwagner@gcc.edu

Ashley Miller, Randon Hoselton, Shannon Armstrong, Grove City College

We have developed taxonomies of alternate conceptions concerning buoyancy and density (see companion posters), and we are investigating the prevalence of many of those conceptions in the college student population at Grove City College (GCC) and other collaborating institutions. We conducted interviews with 14 GCC students during the 2013-2014 academic year. Additionally, students at GCC and collaborating institutions completed a Likert-style "conception survey" probing agreement with selected conceptions. This poster will present preliminary data from the interviews and conception surveys.

PST1E04: 9:15-10 p.m. Compartmentalization of Energy Concepts

Poster – Timothy A. French, DePaul University, 1110 W Belden Ave., Chicago, IL 60614; tfrench4@depaul.edu

Lauren A Macur Brousil, Emma E Balison, DePaul University

We are interested in learning how students compartmentalize concepts related to the universal idea of energy. Often students segregate facets of energy to specific scientific domains. For example, heat and temperature are often put in the realm of chemistry, whereas translational kinetic energy is thought of as physics. Through semi-structured interviews with students and faculty, we hope to determine which facets of energy are pigeonholed into which scientific domains by categorizing and interpreting the language used by the interview subjects. We also hope to better understand the reasons behind this compartmentalization upon analyzing the interview transcripts and finding commonalities in the obtained responses. By learning more about how and why compartmentalization occurs, instructors can better understand and pinpoint the conceptual barricades that exist in order to efficiently and effectively break them down and increase student learning.

PST1E05: 8:30-9:15 p.m. Delving Deeper: Exploring Differing Performance in Studio and Lecture Courses*

*Poster – Caleb C. Kasprzyk,** University of Central Florida, 125 SW Lancaster Ave., Port Saint Lucie, FL 34984; caleb.kasprzyk@knights.ucf.edu*

Matthew Wilcox, Archana Dubey, Jarrad W.T. Pond, Jacquelyn J. Chini, University of Central Florida

Typical comparisons of normalized gains have shown improved performance on concept inventories in a second-semester algebra-based studio-mode courses compared to a lecture-mode course taught by the same instructor with similar curricula. There could be several reasons for this increased performance; for example, students in the studio course could perform better on all topics or only particular topics. Here, we explore whether other recently promoted strategies for analyzing concept inventory data help us to better understand the differences between these courses. We apply both question-level gain and loss analysis and differential item functioning to our data set, which includes nine semesters of studio courses and four semesters of lecture courses.

*This work is supported in part by the U.S. National Science Foundation under grant DUE-1246024 and grant DUE-1347515.

**Sponsored by Jacquelyn J. Chini

PST1E06: 9:15-10 p.m. Developing and Evaluating a Quantum Interactive Learning Tutorial on a Quantum Eraser

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We are developing and evaluating a quantum interactive learning tutorial (QuILT) on a quantum eraser for students in upper-level quantum mechanics. The QuILT exposes students to contemporary topics to 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 experiments and simulations students learn from in the QuILT uses a Mach-Zehnder Interferometer with single photons. We also discuss findings from a preliminary in-class evaluation.

PST1E07: 8:30-9:15 p.m. Developing and Evaluating an Interactive Tutorial on Mach-Zehnder Interferometer with Single Photons

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

Emily Marshman, University of Pittsburgh

We are developing and evaluating a Quantum Interactive Learning Tutorial (QuILT) on a Mach-Zehnder Interferometer with single photons to expose upper-level students in quantum mechanics courses to contemporary applications. The QuILT strives to help students develop the ability to apply fundamental quantum principles to physical situations and explore differences between classical and quantum ideas. The QuILT adapts visualization tools to help students build physical intuition about quantum phenomena and focuses on helping them integrate qualitative and quantitative understanding. We also discuss findings from an in-class evaluation. We thank the National Science Foundation for support.

PST1E08: 9:15-10 p.m. Developing and Evaluating Quantum Mechanics Formalism and Postulates Survey*

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

Development of multiple-choice tests related to a particular physics topic is important for designing research-based learning tools to reduce the difficulties related to the topic. We explore the difficulties that the advanced undergraduate and graduate students have with quantum mechanics formalism and postulates. We developed a research-based multiple-choice survey that targets these issues to obtain information about the common difficulties and administered it to undergraduate and graduate students. We find that the advanced undergraduate and graduate students have many common difficulties with these topics. The survey can be administered to assess the effectiveness of various instructional strategies.

*Supported by the National Science Foundation

PST1E09: 8:30-9:15 p.m. Developing Questions to Assess Causal and Correlational Reasoning Abilities

Poster – Lindsay Owens, The University of Cincinnati, 3843 Mantell Ave., Cincinnati, OH 45236; owensly@mail.uc.edu

Lei Bao, Kathy Koenig, The University of Cincinnati

There has been an increasing push for the refinement of curricula in university-level algebra-based and calculus-based physics classes to focus on reasoning skills in addition to content knowledge. This study gathers and analyzes data for determining the validity and reliability of four questions targeting college physics laboratory students' causal reasoning and correlational reasoning abilities. A modified version of Weidenfeld, Oberauer, & Hörnig's (2005) causal stories assessment was used for two questions and served as a template for the other two. The literature suggests that students entangle causal and correlational scenarios claiming the presence of causal links to correlated variables. This study will serve as a starting point for a larger effort to target students' causal and correlational scientific reasoning abilities within physics laboratory curriculum.

PST1E10: 9:15-10 p.m. Does the Mathematical Complexity of Synthesis Problem Influence Conceptual Performance?*

Poster – Bashirah Ibrahim, Department of Teaching and Learning, The Ohio State University, 1945 N. High St., Columbus, OH 43210-1172 ;BASHIRAH2001@GMAIL.COM

Lin Ding, Daniel White, Ryan Badeau, Andrew Heckler, The Ohio State University

A comparison was made between physics students' conceptual performance and the mathematical complexity of a synthesis problem. Three versions of the problem were designed with increasing levels of mathematical complexity. They all require two concepts, energy conservation, and projectile motion, for problem solving. A rubric was developed for categorizing the students' actions into three levels: (i) recognition of appropriate concepts; (ii) commitment to follow up on the identified concepts; (iii) application of concepts. Scores were also allocated at each rubric level. The sample has an overall better conceptual performance on energy conservation than projectile motion. However, no significant interactions were observed between the students' conceptual performance on energy conservation and the task's mathematical complexity. A similar trend was noted for projectile motion. Mathematical complexity therefore does not seem to influence students' performance in physics, specifically recognition and application of appropriate concepts, when handling the synthesis problem.

*The study is supported by NSF DRL-1252399.

PST1E11: 8:30-9:15 p.m. Does the Pedagogical Learning Bicycle Promote Transfer?*

Poster – Claudia Fracchiolla, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; fracchiollac@ksu.edu

N. Sanjay Rebello, Kansas State University

Research has shown that transfer—defined as the ability of applying what you learned in one context to a different context—can be affected by instructional practices of framing learning context (Engel, et al. 2012). A physics course for future elementary teachers at Kansas State University is structured around the pedagogical learning bicycle (PLB). In this model students learn physics concepts and also learn about how kids learn those concepts. The PLB model frames students' learning around their future careers as elementary teachers, which may promote transfer. In our research we investigate, through student survey and class observation, if the PLB can serve as an instructional model that promotes transfer by facilitating students to expansively frame their learning (Engel, et al. 2012).

*Supported in part by NSF grant 1140855

PST1E12: 9:15-10 p.m. Effect of Manipulating Display Design on Students' Reasoning*

Poster – Bahar Modir, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; bahar@phys.ksu.edu

Elise Agra, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Previous studies have shown that expert students attend to the relevant parts of a problem to activate the corresponding resources, while novice students attend to the irrelevant parts, which leads to activation of incorrect resources. In this study we investigate the role of different kinds of cues on students' reasoning based on Wickens' principle of compatibility and proximity. Cues can direct students' attention to attend to relevant features on the diagram and activate the related resources; however, in addition to activating the relevant resources, students may activate other information based on their intuition or prior knowledge that corresponds to the irrelevant features on the diagram. In research on attention, manipulating different aspects of a display can also be interpreted as a kind of visual cue to facilitate the required perceptual process in the presented task. We investigate how different display designs and cueing attract subjects' attention in processing visual information and activating appropriate resources to solve a problem correctly.

*Supported by the National Science Foundation under Grant 1348857

PST1E13: 8:30-9:15 p.m. Effect of Cues and Video Solutions on Reasoning and Correctness*

Poster – Tianlong Zu, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; zutianlong@gmail.com

Xian Wu, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Online videos are pervasive in our lives and have been used in instruction. Research has shown that visual cueing can be useful in facilitating learning. We investigated how visual cueing and video instructions affect students' performance in solving conceptual physics tasks with diagrams. We conducted think-aloud interviews with students in an algebra-based physics class. Each interview contains four problems sets. Each set of problems contains one initial problem, training problems, a near transfer and a far transfer problem. Visual cues were given during the training session and a video solution to the task was provided after the training session based on the conditions. The effect of visual cueing and video instructions are compared. We will discuss how students' reasoning and correctness were influenced in the two conditions.

*Supported in part by NSF grant 1348857

PST1E14: 9:15-10 p.m. Elective Recitation Sections in Physics Freshman Service Courses

Poster – Steve McCauley, Department of Physics & Astronomy, Cal Poly Pomona, 3801 West Temple Ave., Pomona, CA 91768; SWMCCAULEY@CPP.EDU

Nina Abramzon, Alex Rudolph, Homeyra Sadaghiani, Alex Small, Cal Poly Pomona

Students from 23 departments on the Cal Poly Pomona campus are required to take freshman physics service courses. Many of them struggle to succeed. Introductory physics courses at Cal Poly Pomona do not normally include any recitation sections focused on concepts and problem solving skills. We present data that we used to assess the effectiveness of elective recitation sections as we experimented with different formats.

PST1E15: 8:30-9:15 p.m. Electrostatic Dimensional Transformations Constructed by Novice Physics Students

Poster – Jaclyn Kuspiel Murray, University of Georgia, 4740 Plainsman Circle, Cumming, GA 30028; jakspiel@hotmail.com

Barbara A. Crawford, University of Georgia

Visualization is the meaning-making of representation. Current models and theoretical frameworks neglect to explain a direct link between visualization and conceptual understanding. Findings acquired via empirical research are inconclusive; how best to utilize representation for the purpose of constructing internal visualizations (i.e. mental models) is unclear. An exploration into how introductory undergraduate physics students and pre-service middle school teachers visualize and comprehend electrostatic concepts in relation to representation across dimensional transformations is the focus of this investigation. Both visuospatial ability and initial electrostatics concept knowledge supplement participant construction of 3D representations from 2D schematics, and the design of 2D representations from 3D models. The overall question under examination is how do novice physics students represent electrostatics phenomena in two- and three-dimensions when provided a representation within another dimension? In other words, what strategies do novices employ to make sense of two- and three-dimensional representations?

PST1E16: 9:15-10 p.m. Energy – Momentum – Force – Kinematics: Redesigning the High School Mechanics Curriculum

Poster – Alexander Robinson Thornapple, Kellogg High School, 13836 Hardenburg, Trl Eagle, MI 48822; thegreatmongoose@gmail.com*

Alicia C. Alonzo, James Brian Hancock II, Michigan State University

While much of the early research on "misconceptions" focused on the rationality of these ideas, current physics curriculum materials and assessments emphasizing well-documented "misconceptions" about mechanics seek to "root out" students' intuitive ideas and to replace them with the correct scientific ones. Yet by the time students enter high school physics classrooms, these ideas have worked well in over a decade of experience interacting with moving objects. Thus, over the past three years, we have engaged in iterative cycles of curriculum design research, exploring whether we can leverage (rather than root out and replace) students' intuitive ideas about motion by reversing the order in which mechanics topics are typically taught in high school physics. Drawing on classroom videos, weekly video-recorded student cognitive interviews, and student responses to a multiple-choice diagnostic assessment administered five times each semester, we describe how student thinking develops using our redesigned curriculum.

*Sponsored by Alicia Alonzo

PST1E17: 8:30-9:15 p.m. Enrollment Fluctuation: Effect on Qualitative In-Class Data Analysis

Poster – Andrew J. Mason, University of Central Arkansas, Department of Physics and Astronomy, Conway, AR 72035-0001; ajmason@uca.edu

Charles A. Bertram, University of Central Arkansas

Audiovisual data of an in-class group problem-solving exercise was taken during two different semesters of a first-semester introductory algebra-based physics course. The spring 2014 semester's course reflected a distribution of majors typical of most semesters. However, a one-time unanticipated shift in enrollment occurred, from a plurality of life science majors in the spring 2014 semester course to a plurality of health science majors (who reside in a separate college from the Department of Physics and Astronomy) in the fall 2014 semester course. We examine qualitative data of lab group performance to examine whether certain trends appear consistent between semesters and which trends do not, e.g. stability of laboratory groups and ability to finish a more complex problem within an allotted time of 50 minutes.

PST1E18: 9:15-10 p.m. Enrollment Fluctuation: Effect on Quantitative Assessment of Student Attitudes

Poster – Andrew J. Mason, University of Central Arkansas, Department of Physics and Astronomy, Conway, AR 72035-0001; ajmason@uca.edu

Charles A. Bertram, University of Central Arkansas

An unanticipated fluctuation in student enrollment trends may influence students' interpretation of and response to a given instructional interpretation, with respect to prior class sections for a given instructor. In an algebra-based introductory physics course for a given instructor, a one-time unanticipated shift in enrollment occurred, from a plurality of life science majors in the spring 2014 semester course to a plurality of health science majors (who reside in a separate college from the Department of Physics and Astronomy) in the Fall 2014 semester course. We discuss possible effects this fluctuation had on interpretation of quantitative pre-post data taken of student attitudes and force concepts, e.g. differences in pretest data and whether trends hold by major from semester to semester. We also investigate whether any data trends are robust enough to withstand a one-semester enrollment fluctuation, and whether other demographic shifts may have occurred and/or influenced results.

PST1E19: 8:30-9:15 p.m. Establishing Reliability When Coding for Resources

Poster – Darrick C. Jones, Rutgers University, Department of Physics and Astronomy, 136 Frelinghuysen Rd., Piscataway, NJ 08854-8019; dcjones@physics.rutgers.edu

Johanna Doukakis, Eugenia Etkina, Rutgers University

The resource-based model of cognition has helped provide physics educators with a deeper understanding of the fine-grained mechanics of student reasoning. However, a multitude of studies that utilize the resource-based model of cognition rely strictly on qualitative analyses. While these studies are important and necessary, their nature limits the scope of knowledge that we can gain using the resource-based model of cognition. Adopting a mixed methods approach can help us uncover and communicate patterns in data that we would not be able to find if we only used a qualitative approach. To adopt a mixed methods approach, we must develop coding schemes to reliably code for resources. In this poster we present a coding scheme for identifying resources and discuss how we have achieved reliability using these methods.

PST1E20: 9:15-10 p.m. Evaluating Teaching Assistant Actions in Recitations and Inquiry-based Labs*

Poster – Matthew Wilcox, University of Central Florida, 2713 Chaddsford Cir. 205, Oviedo, FL 3276;5 mwilcox1@knights.ucf.edu

Caleb C. Kasprzyk, Jarrad W.T. Pond, Jacquelyn J. Chini, University of Central Florida

Through the use of the Real-time Instructor Observing Tool (RIOT) we evaluate the effects of TA actions in mini-studios, which combine student-centered recitations with inquiry-based labs. TA actions observed include open or closed dialogue, passive or active observing, and clarifying or explaining to students. We observe multiple TAs teaching algebra-based first-semester physics labs to approximately 30 students per section. Individual TAs create an action profile that consists of the proportion of time spent on each action for that specific TA. These action profiles are found by averaging the duration of TA actions across multiple labs for a single TA. We explore the relationship between prevalent or non-prevalent actions to students' normalized gains on the Force Concept Inventory (FCI) and their responses to the Colorado Learning Attitudes about Science Survey (CLASS).

*This work is supported in part by the U.S. National Science Foundation under grant DUE-1246024.

PST1E21: 8:30-9:15 p.m. Evaluation and Evolution: Twenty Years of Studio Physics at Rensselaer

Poster – Peter D. Persans, Rensselaer Polytechnic Institute, 110 Eighth St.,Troy, NY 12180-3590; persap@rpi.edu

Scott R. Dwyer, Eric S. Deutsch, Rensselaer Polytechnic Institute

Since its introduction in 1993, nearly 1,000 STEM students per semester have taken either calculus-based Physics 1 or Physics 2 in some variety of "Studio Physics" at Rensselaer Polytechnic Institute. As introduced, Studio Physics integrated short lectures, collaborative group work, and experimental activities into two 2-hour classes per week for each of 20 sections taught in parallel. The goal of the Studio model was to more actively engage students in teaching themselves and one another. Physics 1 (Mechanics) has been maintained in a closely related format since that time. Starting in 2007, Physics 2 (Electromagnetics and Quantum Physics) has been taught in a variety of related models with the goal of increasing student engagement in student-centered, collaborative learning. We will report the effects of teaching model on both student performance and student course evaluations.

PST1E22: 9:15-10 p.m. Exploring Student Reasoning Using Item Response Curves

Poster – Alexander M. Axthelm, University of Maine, 214 Bennett Hall, Orono, ME 04469; alexander.axthelm@maine.edu

Michael C. Wittmann, Carolina Alvarado Leyva, Laura Millay, University of Maine

As part of a larger project to study middle school teachers' knowledge of their students' ideas, the Maine Physical Sciences Partnership (NSF #0962805) has developed a multiple-choice survey on energy that has been administered to thousands of students. We analyze our results using a modified version of Item Response Theory which does not focus on correctness of answers but instead focuses on the ideas that students use when choosing their answers. In this talk, I will present a coding scheme which goes beyond the "correct/incorrect" paradigm, and looks at the possible lines of thought that could lead a student to a particular response. By comparing ideas used across many questions, we can conclude which resources are most productive for students. I use these results to describe productive student reasoning about energy on this survey.

PST1E23: 8:30-9:15 p.m. From Instructional Goals to Grading Practices: The Case of Graduate TAs

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Alexandru Maries, Chandralekha Singh, University of Pittsburgh

Edit Yerushalmi Weizmann, Institute of Science

Charles Henderson, Western Michigan University

Teaching assistants (TAs) are often responsible for grading student solutions. Grading communicates instructors' expectations, thus TAs have a crucial role in forming students' approaches to problem solving in physics. We investigated the grading practices and considerations of 43 first-year graduate students participating in a TA training course. The study utilized four student solutions, selected to reflect expert and novice approaches to problem solving and to elicit conflicting considerations in assigning grades. TAs were asked to list solution features and to explain how and why they weighed the different features to obtain a final score. We will describe how discussions of grading practices in the course, as well as one semester of teaching experience, impacted how the TAs grade student solutions. We will relate our results to the findings of a larger study to understand instructors' considerations regarding the learning and teaching of problem solving in an introductory physics course.

PST1E24: 9:15-10 p.m. Group Work in an IPLS Course

Poster – Erin M. Scanlon, Texas State University, 2207 Wickershan Lane, Apt. 612, Austin, TX 78741; emscanlo@gmail.com

In this poster session I will present data collected from observations of students working together to solve introductory physics problems. Introductory algebra-based physics courses composed mainly of students majoring in the life sciences at a small, liberal arts college in central Texas were observed. Data analysis focused on how students negotiate and work together to solve problems in a laboratory setting and to comparing students individual and group problem solving habits.

PST1E25: 8:30-9:15 p.m. Examining the Effects of Testwiseness Using the Force Concept Inventory

Poster – Seth T. DeVore, West Virginia University, 45 Grandview Ave., Morgantown, WV 26506-0002; 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) that contain distractors, the selection of which can be related to the use of testwiseness strategies. We further examine the effects of both the positive and potential negative effects of testwiseness on student scores by developing two modified versions of the FCI designed to include additional elements related to testwiseness. Details of the development of the modified versions of the FCI and the effect sizes measured in all versions of the FCI will be discussed.

PST1E26: 9:15-10 p.m. Growth Mindset In the Details: Overlapping Interests Projects in Physics

Poster – Angela Little, Michigan State University, 1464 W Farragut Ave. #2, Chicago, IL 60640; little@berkeley.edu

Vashti Sawtelle, Michigan State University

Growth mindset, an important construct studied mainly in psychology, has been shown to correlate with math improvement and success in K-16. Typically, the construct of growth mindset has been measured through large-N surveys asking students about whether it's possible to become more intelligent or talented. In this exploratory work, we ask: how might we adapt the construct of growth mindset to understand students' introductory college physics experiences? In particular, we draw on one-on-one student interviews to begin to develop a qualitative framework. This would allow for tracking growth mindset in the details to better understand what affects it. Our interviews also address Overlapping Interests Projects: in-depth projects where students bring together their core interests with physics to answer an open-ended question over a semester. Students complete these projects as part of their introductory physics experience, and we examine it as a place where growth mindset is most likely to develop.

PST1E27: 8:30-9:15 p.m. Helping Students Solve Quantitative Physics Problems Involving Strong Alternative Conceptions*

Poster – Shih-Yin Lin, National Changhua University of Education 1, JinDe Rd., Changhua, 500 Taiwan; hellosilpn@gmail.com

Chandralekha Singh, University of Pittsburgh

It is well-known that introductory physics students often have alternative conceptions that are inconsistent with established physical principles and concepts. Invoking alternative conceptions in quantitative problem-solving process can derail the entire process. In order to help students solve quantitative problems involving strong alternative conceptions correctly, appropriate scaffolding support can be helpful. The goal of this study is to examine how different scaffolding supports involving analogical problem solving to influence introductory physics students' performance on a target quantitative problem in a situation where many students' solution process is derailed due to alternative conceptions. Three different scaffolding supports were designed and implemented in calculus-based and algebra-based introductory physics courses involving 410 students to evaluate the level of scaffolding needed to help students learn from an analogical problem that is similar in the underlying principles involved but for which the problem solving process is not derailed by alternative conceptions. We will present the findings.

*This work is supported by NSF.

PST1E28: 9:15-10 p.m. How Does Laboratory Reform Affect Students' Learning Attitudes?

Poster – Zeynep Topdemir, Georgia State University, One Park Place, 4th Floor, Atlanta, GA 30303; ztopdemir1@gsu.edu

David N. Trusty, Brian D. Thoms, Georgia State University

The Physics Education Research Group at Georgia State University has reformed the laboratory format of calculus-based introductory physics courses in order to improve students' understanding. The redesign converted traditional three-hour experiments into one-hour tutorials and two-hour inquiry-based experiments. In the first hour, University of Washington tutorials are led by undergraduate Learning Assistants with the assistance of graduate Teaching Assistants (TA). For the remaining two hours, TAs guide students in inquiry-based experiments with a main goal of improved conceptual understanding. Over 150 students in the first course in the sequence (mechanics) and completed the Force Concept Inventory (FCI) and Colorado Learning Attitudes about Science Survey (CLASS) pre- and post-instruction before the lab reform in the fall 2013 and after lab reform in fall 2014. This study will compare the shifts in students' learning attitudes before and after the redesign in order to examine how learning attitudes change. We also report the effect of the redesign on learning gains as seen from FCI scores. This study reveals the effects of the laboratory reformation on students' attitudes and conceptual understanding in introductory.

PST1E29: 8:30-9:15 p.m. How Would Multimedia Hints Affect Physics Problem Solving Performance*

Poster – Xian Wu, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; xian@phys.ksu.edu

Tianlong Zu, John Hutson, Lester C. Loschky, N S. Rebello, Kansas State University

The long-term purpose of this study is to facilitate the creation of useful hints in computer-assisted instruction for a nearly infinite variety of problems involving graphs and figures. Since computer-assisted instruction usually involves auditory, text, or visual animation, the outcome of those different modalities should be tested. We recruited 144 pre-service elementary teachers for our study, which showed that different hint modalities enabled our participants to perform physics problem solving differently. According to our results, the Multimedia Learning Theory may need to be revised in order that we may provide improved guidance toward building effective assistance in order to facilitate physics problem solving.

*This research is supported in part by the U.S. National Science Foundation under Grants 1138697 and 1348857. Opinions expressed are those of the authors and not necessarily those of the Foundation.

PST1E30: 9:15-10 p.m. Impacting Self-Efficacy Through Overlapping Interests Projects in Introductory Physics

Poster – Vashti A. Sawtelle, Michigan State University, 867 Wilson Rd., East Lansing, MI 48824-1046; vashti.sawtelle@gmail.com

Angela Little, Michigan State University

Educational psychology studies have linked self-belief constructs to success in STEM, including self-efficacy (the belief in one's ability to succeed at specific tasks) and growth mindset (seeing intelligence as something that can be developed through dedication and effort). However, most of the work with these constructs uses traditional psychology large-N quantitative studies that show that change happens without describing in qualitative detail the mechanism by which it happens. This presentation will focus on efforts to develop a framework to explore these mechanisms. We build from a case study of experiences in an in-depth course project that was completed in conjunction with an introductory physics course. We present evidence from this case that even a student who sees herself as competent in the sciences, still sees physics as particularly difficult. We will explore the ways in which this overlapping interests project created opportunities to impact students' sense of competence in physics.

PST1E31: 8:30-9:15 p.m. Improving Knowledge Transfer Skills and Attitudes in Physics for Pre-Med Majors in an Hispanic-Serving Institution

Poster – Liang Zeng, The University of Texas-Pan American, 1201 W. University Dr., Edinburg, TX 78539; zengl@utpa.edu

Most professors at the University of Texas-Pan American, an Hispanic Serving Institution, perceive pre-med majors to have relatively weak backgrounds in high school physics and math and have little interest in learning physics at a deep level. They also feel that many students only want to get high grades so that the transcripts look good. The general physics courses consist of mechanics, fluids, heat, waves, sound, electricity, magnetism, optics, atomic physics, and nuclear physics. The prerequisite for the course is college algebra. Through implementing various teaching methods including curriculum alignment with MCAT standards, classroom demonstrations, problem-solving examples within various contexts, just-in-time teaching and psychological safety, we found that we can possibly improve student knowledge transfer skills and attitudes towards learning physics. The significance of this pilot research study is that it has potential to impact a significant number of pre-med students in learning physics at the college and university levels.

PST1E32: 9:15-10 p.m. Improving Students' Understanding of Lock-In Amplifiers*

Poster – Seth T. DeVore, West Virginia University, 45 Grandview Ave., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu

Chandralekha Singh, University of Pittsburgh

A lock-in amplifier (LIA) is a versatile instrument frequently used in physics research. However, many students struggle with the basic operating principles of a LIA which can lead to a variety of difficulties. To improve students' understanding, we have been developing and evaluating a research-based tutorial that utilizes a computer simulation of a LIA. The tutorial is based on a field-tested approach in which students realize their difficulties after predicting the outcome of simulated experiments involving a LIA and check their predictions using the simulation. Then, the tutorial guides and helps students develop a coherent understanding of the basics of a LIA. 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.

*This work is supported by the National Science Foundation.

PST1E33: 8:30-9:15 p.m. Influence of Learning in the School on Students' Energy Concepts

Poster – Seo Bin Park, Seoul National University of Education, Seocho-gu seochojungang-ro, 96 Seoul, 1 137-742 South Korea; jinakr@sen.go.kr

Youngseok Jhun, Seoul National University of Education

Pupils construct concepts on energy, fundamental in science, in their everyday lives as well as learning in school. However, the meanings of abstract energy concepts are slightly different from those in a science context. We'd like to know how it affects the pupils' concepts to learn energy in school. We examined the words elementary school students had associated, before and after the energy classes, in the viewpoint of those quantities, contents, and the structure of the mind map they have made. We also analyzed the relation between learning contents on energy at school with the conceptual change. We considered the students' achievements as an important variable. We will draw up some implementations of energy education in the school; the importance and the role of formal education.

PST1E34: 9:15-10 p.m. Integrating Scientific Practices into Introductory Physics Assessments

Poster – James T. Laverty, Michigan State University, 620 Farm Lane, Room 115 East Lansing, MI 48824-1046 laverty1@msu.edu

Stuart H. Tessmer, Sonia M. Underwood, Melanie M. Cooper, Marcos D. Caballero, Michigan State University

The Physics and Astronomy Department at Michigan State University recently began to redesign its introductory physics courses. At the center of this transformation effort is an attempt to include scientific practices, crosscutting concepts, and core ideas in the assessments and instruction of the courses. As part of a research effort, we have been developing the Three-Dimensional Learning Assessment Protocol (3D-LAP) to characterize how assessments used in introductory courses change over time. This instrument provides criteria by which scientific practices, crosscutting concepts, and core ideas can be identified within assessment items. Additionally, this instrument can be used to help write new assessment items or improve existing ones. This poster will focus on the 3D-LAP and using it to track changes in assessments over time as well as to build assessment items that incorporate all three dimensions.

PST1E35: 8:30-9:15 p.m. Learning Introductory Physics via Web-based Tutorials and Scaffolded Prequizzes

Poster – Seth T. DeVore, West Virginia University, 45 Grandview Ave., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu

Chandralekha Singh, University of Pittsburgh

Web-based tutorials based upon research in teaching and learning of physics can be a useful self-study tool for increasing exposure to expert like problem solving strategies in introductory physics in which the student population is generally quite diverse. One challenge with web-based self-study tools is that the level of student participation and engagement with these tools depends on how disciplined students are and what value they discern in learning from these tools. We developed both a set of web-based tutorials and scaffolded prequizzes designed to improve introductory students' understanding of physics. The scaffolded pre-quizzes mirror the structure of web-based tutorials developed via research and can be implemented in the classroom where participation from all students is easier to mandate. We discuss investigation of the effectiveness of the web-based tutorials and scaffolded prequizzes and weigh on the strengths and weaknesses of each intervention. We thank the National Science Foundation for support.

PST1E36: 9:15-10 p.m. Negotiating Positionings within Small Groups in Introductory Physics

Poster – May H. Lee, 620 Farm Lane, 301E Erickson Hall, East Lansing, MI 48824; leemay1@msu.edu

Vashti Sawtelle, David Stroupe, Marcos D. Caballero, Alicia Alonzo, Michigan State University

To provide opportunities for students to engage meaningfully with core disciplinary concepts and practices in physics, an introductory calculus-based mechanics course was designed so students collaborated in small groups to solve complex story problems. Our research focuses on how collaboration between group members affects their opportunities to learn and do physics. Qualitative methods were used to analyze video-recorded small group discussions over a three-week period. The dynamics of the social interactions between group members were analyzed through positioning theory (Davies & Harré, 1990). Preliminary findings indicate that group members seemed to position themselves as capable of doing physics. Additionally, each group member was positioned by his or her peers and/or instructor as either more or less knowledgeable in doing physics. As a work in progress, we report on how students negotiate these positionings from multiple sources.

PST1E37: 8:30-9:15 p.m. Perceptions of Learning and Teamwork: Practice-based Introductory Physics

Poster – James Brian Hancock, II, Michigan State University, 250C Erickson Hall, East Lansing, MI 48824; hancoc14@msu.edu

Paul Irving, Marcos (Danny) Caballero, David Stroupe, Vashti Sawtelle, Michigan State University

At Michigan State University, one section of a calculus-based introductory physics course for scientists and engineers has been transformed to focus on developing students' use of scientific practices (e.g., developing and using models, designing experiments, using computational modeling) through participation in a community-based learning environment. We present qualitative data from interviews with students based on their participation in the calculus-based course, which we call Projects and Practices in Physics (P3). In this course, students learn core physics concepts by engaging with scientific practices. The researchers investigated student perceptions of learning through the practices developed in P3. Preliminary results on the perception and nature of teamwork and learning in this environment (and how those perceptions are connected) will be presented, as well as potential implications to consider when incorporating scientific practices and alternative teaching methods in undergraduate introductory physics courses.

PST1E38: 9:15-10 p.m. Professional Development of Physics Teacher Leaders in a Professional Learning Community (PLC)

Poster – Smadar Levy, Weizmann Institute of Science, 22 Zufit St., Hod Hasharon, Israel 45354; smadarlevy@gmail.com*

Bat Sheva Eylon, Esther Bagno, Hana Berger, Weizmann Institute of Science

A physics teaching team at WIS enacts a PLC of physics teacher-leaders leading 10 regional PLCs of high-school physics teachers (200 teachers) all over Israel. The PLCs aim to develop student-centered and engaging teaching. Using a "fan model" led by the WIS team, 25 physics teacher-leaders meet every two weeks for four hours throughout the year preparing the consecutive meetings of their PLCs. Prior to these meetings, the teacher-leaders engage as learners in research-based teaching strategies; implement customized-versions in their classes; reflect collaboratively with peers on evidences from their practice; and conceptualize the learning process. These stages act as a model for running their own PLCs and are supported there by insights gained in the previously described process. Research indicates that the teacher-leaders develop a strong sense of community; deepen physics knowledge (CK) and pedagogical content knowledge (PCK); and acquire leading skills. The rational and the model will be elaborated.

*Sponsored by Bat Sheva Eylon

PST1E39: 8:30-9:15 p.m. Putting the Puzzle Pieces Together: Teachers' Reasoning About Student Thinking

Poster – Alicia C. Alonzo, Michigan State University, 620 Farm Lane Blvd., Room 307, East Lansing, MI 48824; alonzo@msu.edu

Andrew Elby, University of Maryland

Learning progressions (LPs)—descriptions of increasingly sophisticated ways of thinking—are influencing materials for teachers. Underlying much of this work is a strong, though often tacit, assumption that students' conceptual thinking is theory-like and context-independent. Yet theoretical perspectives (e.g., naïve conceptions, knowledge-in-pieces) and empirical evidence suggest more fragmented models of student thinking. Interested in this potential mismatch, we explored how high school physics teachers reasoned about student thinking when presented with LP-based diagnostic information. While teachers were able to make sense of the LP perspective, they tended to treat student thinking about force and motion as less coherent. Each teacher switched among several different perspectives to interpret the information provided, with variation in the amount of structure they attributed to the "pieces" comprising understanding of force and motion. We consider how these results can inform LP-based professional development that leverages teachers' multiple perspectives about student cognition.

PST1E40: 9:15-10 p.m. Quantum Interactive Learning Tutorial (QuILT) on Quantum Key Distribution*

Poster – Seth T. DeVore, West Virginia University, 45 Grandview Ave., Morgantown, WV 26506-0002; stdevore@mail.wvu.edu

Chandralekha Singh, University of Pittsburgh

We are developing and assessing a quantum interactive learning tutorial

(QuILT) on quantum key distribution to expose students to contemporary applications of quantum mechanics. One protocol used in the QuILT on quantum key distribution involves generating a shared key over a public channel for encrypting and decrypting information. One protocol uses single photons with non-orthogonal polarization states, while another protocol makes use of entanglement. The QuILT actively engages students in the learning process and helps them build links between the formalism and the conceptual aspects of quantum physics without compromising the technical content. Details of the development and assessment will be discussed.

* This work is supported by the National Science Foundation.

PST1E41: 8:30-9:15 p.m. Relating the Car and Passenger Problem to the FVA Test

Poster – Jennifer Blue, Miami University, 500 E Spring St., Oxford, OH 45056; bluejm@miamioh.edu

The Car and Passenger Problem, attributed to Patricia Heller, University of Minnesota, is notoriously difficult for students. (See Blue, Second Law or Real Forces? PERC 2013, and Blue, Examining Students' Reservations about Forces, AAPT W2013.) Among the difficulties students have is confusion relating the direction of net forces to direction of acceleration, which is addressed by the FVA Test (Rosenblatt & Heckler, PRST-PER 7[020112], 2011). In this study, student performance on key questions from the FVA Test is related to performance on the Car and Passenger problem. Data was taken from 80 students in a second-semester calculus-based physics class, several months after their instruction on forces.

PST1E42: 9:15-10 p.m. Self-Regulation and Performance in Introductory Physics

Poster – John C. Stewart, West Virginia University, 235 White Hall, Morgantown, WV 26506; jcstewart1@mail.wvu.edu

Rossina Miller, West Virginia University

This poster examines the degree to which students regulate their study activities and time-on-task in calculus-based introductory physics. Ten years of class performance data from a large public university is combined with self-reported time-on-task and study behavior data collected using a survey instrument. The degree to which student behavior evolves within the semester due to the stimuli of either low or high test grades is presented. The changes in student time use and behavior patterns are also investigated longitudinally as the course studied underwent revision. Students regulate their reported study time for exams as a result of varying exam grades but there is little evidence of regulation of the time investigates in other behaviors such as working homework.

PST1E43: 8:30-9:15 p.m. Student Ability Reasoning with Multiple Variables for Graphed/Non-Graphed Information

Poster – Rebecca J. Rosenblatt, Illinois State University, 218 Willard Ave., Bloomington, IL 61701; rosenblatt.rebecca@gmail.com

Past findings analyzing student difficulties reasoning with data showed that in graphed and pictured cases students were much more likely to incorrectly reason about situations in which a variable has no relationship or an unknown (data is not conclusive) relationship with another variable. Expanding on this, students were given graphs with more data points and multiple trend-lines. Student responses about these more detailed graphs support original findings and allow for some additional distinctions. In addition, students were asked to create their own graphs. These graphs tended to be either a line graph with legend, like the graphs given in the original study, or a bar graph with clusters that showed the third variable. Students' graph style did not affect their ability to answer line-graph questions. Lastly, I present the effects on student reasoning when a set of physical demonstrations equivalent to the pictured phenomena are used to show students the physical data.

PST1E44: 9:15-10 p.m. Student Engagement: Looking Beyond the Classroom

Poster – Brian W. May, Purdue, 230 Marsteller St. Apt. 1, West Lafayette, IN 47906-3923, bwmay@purdue.edu

Rebecca Lindell, Andrew Hirsch, Purdue

Andrew Gavrin, IUPUI

Measuring student engagement is often looked at as an in-class activity only. However, looking at students' involvement in their courses beyond the classroom reveals hidden dynamics factoring into students' learning. Course Networking (CN) is a course management system (CMS) designed to provide a medium for students to engage socially/academically outside of the classroom. In our study, we utilized both qualitative and quantitative research techniques to evaluate each student's engagement outside of the course. By comparing this evaluation to the students' respective grades we hope to determine if there is any correlation between CN use and final course grade.

PST1E45: 8:30-9:15 p.m. Student-Made Video Solutions as Comprehension and Peer Instruction Tools

Poster – Gerardo Giordano, King's College, 133 N. River St., Wilkes-Barre, PA 18711; gerardogiordano@kings.edu

Artur Tsobanjan, King's College

We describe the implementation of an assignment requiring students to record video solutions to homework problems in a college- level calculus-based introduction to mechanics. The videos are uploaded to the course website and available to all enrolled students. We expect that the level of understanding required in order to create an effective video presentation, and the element of peer instruction available to the other students, enhances the learning experiences of both the presenters and their audience. We investigate the effects of this tool on the students' comprehension by means of the Force Concept Inventory Test, regular exams, and a dedicated rubric.

PST1E46: 9:15-10 p.m. Students' Own Words: The Automated Analysis of Constructed Response Project

Poster – Matthew M. Steele, 320 S Magnolia Ave., Lansing, MI 48912; steele24@msu.edu

Mihwa Park, Mark Urban-Lurain, Michigan State University

Constructed response questions (short-answer, open ended items) have the potential to provide insight into student thinking about the core concepts of STEM fields. The Automated Analysis of Constructed Response (AACR, www.msu.edu/~aacr) Research Group is focused on making these assessment tools more accessible to instructors of large enrollment courses by 1) developing a research-based body of constructed response questions addressing a wide range of STEM topics, 2) constructing a system to automatically analyze these items, and 3) fostering Faculty Learning Communities at multiple institutions to support instructors employing the AACR products in their classrooms. In this poster we discuss the goals and current work of the ACCR Research Group, with emphasis placed on the new work in physics and astronomy.

PST1E47: 8:30-9:15 p.m. The Development of Purdue's Computerized Interactive Teaching Assistant (CITA)

Poster – Cyrus M. Vandrevala, Purdue University, 2737 Wyndham Way, West Lafayette, IN 47906; cyrus.vandrevala@gmail.com

Hisao Nakanishi, Laura Pyrak-Nolte, Rebecca Lindell, Andrew Hirsch, Lynn Bryan, Purdue University

Building off CPlite from the University of Illinois at Urbana-Champaign (UIUC), Purdue University developed the Computerized Homework in Physics (CHIP) system in 1997. Due to its success at Purdue, we are developing a Computerized Interactive Teaching Assistant (CITA) for the next generation of CHIP. We aim to extend the ideas behind the interactive examples created at UIUC, raising them to a higher level of interaction between the students and the online learning tool, by applying the current findings of multimedia learning and physics education research. Unlike most computerized homework systems for physics that only provide students with a "correct" or "incorrect" response to their answers, the CITA program will guide students through fundamental concepts and appropriate problem solving techniques. It will provide students with dynamic feedback to their responses, thus allowing them to learn from their mistakes as they analyze each problem.

PST1E48: 9:15-10 p.m. The Effects of Formative Feedback in Introductory Physics

Poster – Paul W. Irving, Michigan State University, 1310D Biomedical and Physical Sciences Building, East Lansing, MI 48844; paul.w.irving@gmail.com

Marcos D. Caballero, Vashti Sawtelle, Michigan State University

An important focus of the Projects and Practices in Physics (P^3) classroom at Michigan State University is the development of scientific practices. However, it is difficult for students to learn scientific practices, such as communicating scientific information or constructive argumentation, without feedback based on observing students engaging in these practices. As part of the instruction in P^3, students are provided with written feedback that is aimed at guiding the students in the appropriation of scientific practices. Through interviews, we examine student's reflections on their interpretation of the purpose of the feedback and what effect if any it had on their participation. Through observational analysis using video of the P^3 classroom, we also interpret the effect that feedback had on each group. By understanding how students respond to feedback, we can investigate how it aids in the appropriation of scientific practice and the development of an identity as a scientist.

PST1E49: 8:30-9:15 p.m. Towards Understanding How Computation Influences Group Discourse in Introductory Mechanics

Poster – Michael J. Obsniuk, Michigan State University, Biomedical Physical Sciences, 567 Wilson Rd., Room 1310B, East Lansing, MI 48824-1046; obsniukm@msu.edu

Marcos (Danny) Caballero, Paul W. Irving, Michigan State University, CREATE For STEM Institute

With the advent of high-level programming languages capable of quickly rendering three-dimensional simulations, the inclusion of computers as a learning tool has exploded in the classroom. Although work has begun to study the patterns seen in implementing and assessing computation in introductory physics, more insight is needed into the mechanisms by which groups of students come to view the computer as a useful tool for "doing" physics. In a newly adopted format of introductory calculus-based mechanics, called Projects and Practices in Physics, groups of students work on short modeling projects – which make use of a novel inquiry-based approach – to develop their understanding of both physics content and practice. Preliminary analyses of observational data of groups engaging with computation, coupled with synchronized computer screencast, demonstrate the different mechanisms groups employ in developing an understanding of physical concepts through computation.

PST1E50: 9:15-10 p.m. Unpacking the Reasoning Behind Newton's Second Law

Poster – Eugene T. Torigoe, 169 Reynolds Ave., Meadville, PA 16335; etorigoe@thiel.edu

A recent article by Fredlund et al[1] described the importance of the unpacking of complex physics representations. One particular example of a concept that has been condensed over time is the concept underlying Newton's second law (N2L). There has been a large body of research demonstrating student difficulties with N2L. One aspect of that difficulty is the complex network of reasoning underlying the equation $F_{net} = m*a$. In this poster I will show my attempt to unpack the lines of reasoning underlying N2L. I will also give examples of how I use it as a visual guide to practice reasoning with N2L.

1. Fredlund, Tobias, et al. "Unpacking physics representations: Towards an appreciation of disciplinary affordance." *Physical Review Special Topics-Physics Education Research* 10.2 (2014): 020129.

PST1E51: 8:30-9:15 p.m. Using Eye Tracking Technology to Study Motion Graphs

Poster – Jennifer L. Docktor, University of Wisconsin - La Crosse, Department of Physics, 1725 State St., La Crosse, WI 54601; jdocktor@uwlax.edu

Jose Mestre, University of Illinois at Urbana-Champaign

Elizabeth Gire, University of Memphis

N. Sanjay Rebello, Kansas State University

We will report results from a study that used eye tracking technology to investigate how introductory students and graduate students view and interpret motion graphs. Participants viewed several graphs of position, velocity, or acceleration versus time on a computer screen and were asked to match a region of the graph with a description of the object's motion. We will compare performance on the questions with audio-recorded explanations and eye movements recorded using an eye tracker.

PST1E52: 9:15-10 p.m. Using Peer Review to Improve Laboratory Report Writing

Poster – Scott W. Bonham, Western Kentucky University, 1906 College Heights Blvd., Bowling Green, KY 42101; Scott.Bonham@wku.edu

Brian G. Luna, Western Kentucky University

Technical writing is an important skill for science and engineering students. We have used examples, rubrics and scaffolding to teach writing. We conducted a trial using peer review followed by self-revision, potentially powerful tools for developing writing skills. Students in two physics lab sections submitted formal lab reports each week to the instructor, while in two other sections students wrote four formal reports for peer review, revision, and final submission to the instructor, with brief reports the other weeks. We found that the quality and improvement of writing over the semester of the peer review group generally comparable and in a few areas superior. The majority of both groups thought the peer review approach more effective and preferable, and it also reduced instructor workload. Both data and student feedback indicated that helping students to provide quality, critical feedback to each other is critical for an effective peer review system.

PST1E53: 8:30-9:15 p.m. Using Primary-Trait Analysis to Evaluate a Reformed Engineering Mechanics Course

Poster – David Beardmore, Department of Physics and Astronomy, Purdue University, 525 Northwestern Ave., West Lafayette, IN 47907; dbeardmo@purdue.edu

Andrew Hirsch, Robyn Bylsma, Rebecca Lindell, Purdue University

While using a standardized concept inventory before and after instruction to evaluate a course is standard, previous research* shows that existing concept inventories are not appropriate for use with Matter and Interactions courses. As an alternative, we have utilized Primary-Trait-Analysis (PTA) since 2012 to evaluate our reformed Matter and Interaction Modern Mechanics course at Purdue University. To utilize PTA, we identified the core concepts (primary traits) covered within the course. With this technique, we then total the percentage points scored for each trait on each exam. Finally we normalize these scores by the test averages. This allowed us to judge the success of the course at teaching the different concepts. Results from multiple semesters will be presented.

*M. Caballero, E. Greco, E. Murray, K. Bujak, M. Marr, R. Catrambone, M. Kohlmyer, M. Schatz, Comparing large lecture mechanics curricula using the force concept inventory: a five thousand student study, *Am. J. Phys*. **80** (7) (2012).

PST1E55: 8:30-9:15 p.m. Visual Cueing and Outcome Feedback Influencing Transfer, Retention, and Confidence

Poster – Elise Agra, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506, esgagra@gmail.com

Bahar Modir, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Research has demonstrated that visual cueing and outcome feedback can facilitate problem solving. In this study, we investigate the effects of visual cues and outcome feedback on students' performance on conceptual physics problems with diagrams. Students enrolled in an introductory mechanics course were individually interviewed using a think-aloud protocol. In one interview, students worked through four problem sets, each set containing an initial problem, four isomorphic training problems, a near transfer problem, and a far transfer problem. Students in the cued condition saw visual cues on the training problems, and students in the feedback condition were told whether their responses were correct or incorrect. The students returned after two weeks for a second interview, during which they solved the transfer problems from the first interview. We discuss the influence of both cueing and feedback on students' confidence and performance on the training, transfer, and retention problems.

*This material is based upon work supported by the National Science Foundation under Grant Nos. 1138697 and 1348857.

Tuesday, July 28 Highlights

REGISTRATION:
7 a.m.–4 p.m. Stamp Student Union Foyer

AAPT Fun/Run Walk:
7–8 a.m. Marriott Foyer

Two-Year College Breakfast:
7:30–8:30 a.m. SSU - Pyon Su

Exhibit Hall Open:
10 a.m.–4 p.m. Grand Ballroom

–H.S. Physics Photo Contest Voting Ballroom Lounge
–H.S. Physics Teachers Resource Booth Booth 323
–PIRA Resource Room Ballroom Lounge
–Two-Year College Resource Room Nanticoke
–Tuesday Morning Raffle 10:30 Grand Ballroom
–Tuesday Afternoon Raffle 3:45 Grand Ballroom

KLOPSTEG MEMORIAL LECTURE AWARD
AAPT FELLOWS RECOGNITION:
10:45 a.m.–12 p.m. SSU - Hoff Theater

Retired Physicists Luncheon:
12–1:30 p.m. SSU - Adele's Restaurant

Commercial Workshops:
– It's About Time 9–10 a.m. Margaret Brent A
– Perimeter Inst. 12–1 p.m., 3–4 p.m. Atrium
– Physics 2000 12–1 p.m. Prince George's
– Science First 9:30–10:30 a.m. Prince George's
– Vernier 1–3 p.m. J. Ramon Jimenez
– WebAssign 9–10 a.m. Margaret Brent B

Committee Meetings, 12–1:15 p.m.
–History & Philosophy in Physics B. Banneker B
–Laboratories PHY - 1204
–Physics in Two-Year Colleges B. Banneker A
–PIRA Committee PHY - 1201
–Pre High School Education Charles Carroll A
–Research in Physics Education Charles Carroll B

ANDREW GEMANT AWARD – AINISSA RAMIREZ:
4–5 p.m. SSU - Hoff Theater

Poster Session:
5–6:30 p.m. SSU - Colony Ballroom

Night at the Museum:
6:15–7:45 p.m. College Park Aviation Museum

Demo Show:
8–9 p.m. Physics Building 1410/1412

Session DA: Transitioning to AP 1 & 2 (Panel)

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Physics in High Schools
Date: Tuesday, July 28
Time: 8:30–9:30 a.m.

Presider: John Eggebrecht

Talk with authors of the Redesigned AP Physics program in a panel format about the new algebra-based physics courses: What models might schools use for sequencing and scheduling? What changes in instructional strategies are needed to prepare for the new AP 1 Physics Exam? How can I use the Framework and other College Board resources to plan my course? Why can't I just do what I have been doing and call it AP 1 & 2? We'll compare old Exam items with new items for a practical discussion.

Panelists:

John Eggebrecht, Brooklyn Technical High School, Brooklyn, NY

Robert Morse, St. Albans School, Washington, DC.

Paul Lulai, St. Anthony Village High School, St. Anthony Village, MN

Andy Elby, University of Maryland, College Park, MD

Steve Kanim, New Mexico State University, Las Cruces, NM

Trina Johnson, College Board

Session DB: Attracting Women to Physics and Girls to Science: What Is Working?

Location: SSU - Benjamin Banneker B
Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on Physics in Pre-High School Education
Date: Tuesday, July 28
Time: 8:30–10:15 a.m.

Presider: Adrienne Traxler

DB01: 8:30-9 a.m. Understanding Female Students' Physics Identity Development

Invited – Zahra Hazari, Florida International University, 11200 SW 8th St., Miami, FL 33199; zhazari@fiu.edu

While the gender gap in physics participation is a well known problem, practical strategies that may improve the situation are not well understood. As physics education researchers, we draw on evidence to help inform us of what may or may not be working. To this end, physics identity has proven to be a useful framework for understanding and predicting participation. Drawing on data from national surveys of college students, qualitative case studies in physics classes, and surveys of undergraduate women in physics, we identify several strategies that are predictive of female students' physics identity development from their high school and undergraduate physics experiences. These include discussions of under-representation, positive interactions with male faculty/postdocs/graduate students, participating in research groups, and awareness of issues for women in physics. I will discuss these findings as well as possible mechanisms that explain why these experiences and related strategies are important.

DB02: 9-9:30 a.m. Attracting Girls to STEM Through the SMASH Experience for Girls

Invited – Geraldine L. Cochran, Rochester Institute of Technology, 138 Lomb Memorial Dr., SAU 2312, Rochester, NY 14623; glcsps@rit.edu

Kara Maki, Rochester Institute of Technology

We created the Summer Math Applications in Science with Hands-On

(SMASH) Experience for Girls to engage K-12 girls in STEM through mathematics. Perceived mathematical ability is a key barrier keeping girls from pursuing STEM degrees. This mathematics barrier persists even among prior female participants of informal STEM experiences. The SMASH Experience uniquely addresses this mathematics barrier through its focus on mathematical modeling and self- efficacy. In mathematical modeling, real-world situations are described by mathematical equations that both give fundamental insight into the process and predict outcomes. By connecting everyday activities to mathematical thinking, modeling can be particularly attractive to girls. Self-efficacy helps determine effort, persistence, and resilience. Research shows dramatic increases in mathematical success in students with high self-efficacy. In the SMASH Experience, participants reflect on their own sense of competence through self-affirmation activities aimed to increase their confidence in their own ability to do mathematics.

DB03: 9:30-9:40 a.m. Understanding Middle School Students' Perceptions of Physics by Gender

Contributed – Emily A. Dare, University of Minnesota, 320 LES, 1954 Buford Ave., St. Paul, MN 55108; dare0010@umn.edu

Gillian H. Roehrig, University of Minnesota

This study examines the perceptions of sixth grade students regarding physics and physics-related careers. The overarching goal of this work is to understand similarities and differences between male and female perceptions about physics and how girl-friendly and integrated STEM strategies might affect these perceptions. This explanatory sequential mixed-methods study uses a survey and focus group interviews to understand the similarities and differences of girls' and boys' perceptions of physics and physics-related careers throughout the first-half of the 2014-2015 academic year. Understanding these perceptions may lead to the unearthing of what type of classroom culture fosters students' interest and self-concept in physics. This may further reveal pathways to interest more females in pursuing physics-related careers.

DB04: 9:40-9:50 a.m. Understanding the Longitudinal Impact of High School Physics on Female Students' Physics Identity

Contributed – Jianlan Wang, Florida International University, 11200 S.W. 8th St., AHC-4 Rm 325, Miami, FL 33199; jianwang@fiu.edu

Zahra Hazari, Florida International University

Students enter physics classes with depressed attitudes towards physics compared to the other sciences, particularly in the case of female students. Female students are also more likely to opt out of a second higher-level physics course. Thus, the broad goal of this work is to better understand how to have the most lasting positive impact on female students' attitudes and motivations towards learning physics after a single physics course in high school. Through longitudinal case studies of six female students using a physics identity framework, we explore the most impactful features of students' high school physics experiences. The data is drawn from three years of student interviews, high school physics class observations, and physics teacher interviews. Our results suggest two categories of events with long-term positive impacts: events that would arouse students' excitement or positive emotion and meta-cognitive events that involve explicit refection on the process of physics learning

DB05: 9:50-10 a.m. Girls Exploring Physics: A Workshop for Grade 9-10 Girls

Contributed – Sarah Durston Johnson, Department of Physics, Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6, Canada; sjohnson@sfu.ca

The Physics Department at Simon Fraser University in BC, Canada, has been offering the highly successful Girls Exploring Physics workshops since 2010. These twice yearly half-day workshops, which can accommodate up to 50 girls, are aimed at female students in grades 9 and 10. In this talk we will discuss the workshop design and content which includes two hands-on experiences, a talk on careers in physics and a lunch with women faculty and students. Our goal is to encourage girls to study physics at a stage in their lives when they tend to be losing interest. We will present our results from assessments completed at the end of the workshops and one year later. For example, a survey given to workshop participants one year after their attendance indicated that the participants are more likely than the general female student population to take physics in grades 11 and 12.

DB06: 10-10:10 a.m. The Impact of Targeted Discussions on STEM Students at CSM

Contributed – Libby K. Booton, Colorado School of Mines, Department of Physics, 1523 Illinois St., Golden, CO 80401-1843; lbooton@mymail.mines.edu

Alex T. Flournoy, Kristine E. Callan, Colorado School of Mines

Equality Through Awareness (ETA) is a growing student club at the Colorado School of Mines. ETA's mission is to spread awareness and support for issues faced by underrepresented groups in STEM fields. In addition, ETA serves as an affinity group for the women in physics at Mines. ETA hosts weekly student-only discussions on a variety of topics related to underrepresented groups in STEM. This talk will discuss how the discussions have impacted the attitudes and beliefs of women (and men) in ETA since their introduction in the spring of 2014. This discussion group has also inspired ideas for research-based science outreach events targeted at elementary and middle school girls.

Session DC: Bringing Physics to Life

Location: SSU - Atrium
Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 28
Time: 8:30–10:30 a.m.

Presider: Nancy Beverly

DC01: 8:30-9 a.m. Physics of Cell Migration and Collective Behavior

Invited – Wolfgang Losert, University of Maryland, PSC Rm 1147, College Park, MD 20742-2421; wlosert@umd.edu

Cells migrate, as individuals or groups, to perform critical functions in life from organ development to wound healing and the immune response. Defects in the cell migration machinery are important in many diseases including cancer metastasis. While it has long been known that biochemical signals can control and guide this migration process, the precise targeting and synchronized collective cell motions seen in many living systems indicate additional control mechanisms. Recent research my group and others has demonstrated that the physical properties of the microenvironment can also control and guide migration. I will describe how an underlying wave-like process of the cellular scaffolding drives persistent migration and contributes to the ability of cells to move collectively. I will further show that the same internal waves also allow cells to recognize and follow surface nanotopography on scales comparable to these internal waves. This facilitates contact guidance by the texture of their environment.

DC02: 9-9:30 a.m. Seeing the Light: From the Eye to the Brain

Invited – Rajarshi Roy, Institute for Physical Science and Technology, University of Maryland, College Park, MD 20742-2421; rroy@umd.edu*

Signals from the eye to the brain determine what we see and how we interpret images and the dynamical, changing world around us. We will explore simple and complex aspects of "seeing the light" - from the formation of images to their interpretation based on frames of reference that lead us to impressions of the world around us. Visual illusions and demonstrations with simple apparatus will be used to illustrate how eyes and brain work together to help us navigate our way through life with balance and poise.

*Sponsored by Robert Hilborn

DC03: 9:30-10 a.m. Frankenstein Was Right: Updates from the Science of Animal Electricity

Invited – Dany S. Adams, Tufts University, 200 Boston Ave, Suite 4600, Medford, MA 02155-5555; dany.adams@tufts.edu*

In 1818 Mary Shelley wrote a short story widely believed to be inspired by the activities of Giovanni Aldini, Luigi Galvani's nephew. Shelley's story, "Frankenstein" illustrates the long-prevailing sentiment that studying electricity in animal tissues was of questionable taste, if not downright insane. That sentiment has changed, slowly, due to research on biophysical signaling in nerves and muscles. But those very rapid changes in membrane potential are only part of the story. All cells maintain stable voltages across their membranes, and those voltages inform cells whether to move, reproduce, change gene expression, and/or die. There are now easy-to-use fluorescent voltage (and ion)-reporting dyes that allow us to observe those potentials live, in cells. These dyes, and the signals they so colorfully reveal, illustrate an important intersection of Physics and Biology that could be exploited to teach Biology students that Physics is as excellent and useful as Chemistry.

*Invited by: Nancy Beverly

DC05: 9:30-10:30 a.m. Maybe I Could Use this Again! Two IDEAL Labs Introducing Instrumentation

Poster – Sean Bryant, PO Box 1323, Collegedale, TN 37315; seanbryant@southern.edu

W. Blake Laing, Southern Adventist University

Physics lab students are introduced to custom instrumentation using Arduino-like microcontrollers which have allowed us to implement two labs of particular utility for life-science majors. Constructing a fluid circuit using the sponge-resistor model, flow sensors and an LCD display show the current through each section of pipe. The instrument can simultaneously measure and record 18 voltages, which enables us to record high-frequency "snap shots" of a signal generated on an RC-circuit model of an axon. The IDEAL lab collaboration is developing labs that are open, applied to life, and rigorously quantitative.

DC06: 9:30-10:30 a.m. Physics for Pre-pharmacy: Is a Spirometer Faster than a Racecar?

Poster – Alexander Wong, Prince George's Community College, 301 Largo Rd., Largo, MD 20774; wongax@pgcc.edu

Richard N. Dalby, Kathleen J. Pincus, University of Maryland School of Pharmacy

Pre-pharmacy students and other allied health students are often heavily represented in introductory algebra-based physics classes. Pharmacy school faculty lament the difficulties incoming students have with word problems and math. By introducing clinical and pharmaceutical contexts into a community college algebra-based physics course, collaborating instructors at both institutions hope to improve student engagement and learning while promoting pharmacy career options. The basic concepts of physical motion, traditionally illustrated using calculations describing the acceleration of objects such as a racecars, can be introduced as analogous to concepts in the measurement of breathing (spirometry). For example, physical quantities such as instantaneous velocity are analogous to spirometric quantities such as peak flow. Similarly, graphs representing motion are conceptually similar to spirometric graphs. Early indicators suggest community college students find a spirometeric context to be helpful in developing their understanding of motion and relevant to their interests and career goals.

DC07: 9:30-10:30 a.m. Pressure in the Human Body: Physics of the Respiratory System

Poster – Nancy L. Donaldson, Rockhurst University, 1100 Rockhurst Rd., Kansas City, MO 64110; nancy.donaldson@rockhurst.edu

This NSF-funded curriculum is a hands-on, active learning module covering the mechanics of breathing and the pressure differences in the body that guide air flow in the respiratory system in health and disease. The target learning audience is intermediate-level undergraduates, i.e., students who have already had a one-year introductory-level physics course; however, with the appropriate student background, it could be used in an Introductory Physics for the Life Sciences course. The module activities address Pre-Health Competency E3 (Demonstrate knowledge of basic physical principles and their applications to the understanding of living systems) and Foundational Concept 4B (Importance of fluids for the circulation of blood, gas movement, and gas exchange) and are directed toward an application of physics to medicine. Students particularly interested in these activities may be those pursuing graduate school/careers in medicine, health care, or medical physics or those interested in broadening their understanding of applications of physics.

DC08: 9:30-10:30 a.m. Simulating Soft Matter in High School: The Case of Lipid Rafts

Poster – Edit Menuha Yerushalmi, Weizmann Institute of Science, 234 Herzl St., Rehovot, 7610001 Israel; edit.yerushalmi@weizmann.ac.il

Elon Langbeheim, Arizona State University

Samuel Safran, Weizmann Institute of Science

Computational modeling can be useful for engaging students with relatively little background in statistical mechanics in modeling systems of soft and biological matter. We demonstrate the fundamental knowledge students need for computational modeling of the formation of lipid rafts. Lipid rafts are small domains of saturated lipids (that closely pack) "floating" in an environment of mostly unsaturated lipids (that cannot closely pack) in the cell membrane. An analytical model that predicts the size of the lipid domains is based on a recent theoretical paper (Brewster, Pincus and Safran 2009). We describe the modeling challenges faced by students engaged in a program for interested and talented high school students in constructing a Monte Carlo simulation (in particular, in representing the different types of lipids) and in reproducing the analytical model from the research paper, as well as their evaluation of analytical model vis-a-vis the results of the simulation.

DC09: 9:30-10:30 a.m. Successes and Challenges in Scaling-up NEXUS/Physics Labs: UMD and Beyond

Poster – Kimberly A. Moore, University of Maryland, 6525 Roosevelt St., Falls Church, VA 22043; MoorePhysics@gmail.com

Wolfgang Losert, University of Maryland

Nawal Benmouna, Montgomery College

James Vesenka, University of New England

Simon Capstick, Florida State University

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 in 2013-Present, and adopted at several institutions (including TYCs, R-1 universities, and small 4-year colleges). 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 at UMD. We also have survey data from some of the initial adopting institutions. In this poster, we will provide a broad overview of what we have learned and a comparison of our large-enrollment results and the results from "first adopter" institutions to the results from our pilot study. Special emphasis will be placed on successes and challenges accompanying this scaling-up, both at UMD and beyond.

DC10: 9:30-10:30 a.m. The Mystery of DNA—An Interdisciplinary Student Laboratory

Poster – Becky L. Treu, Moberly Area Community College, Advanced Technology Center, Mexico, MO 65265; beckyt@macc.edu

The increasing complexity of science demands that concepts and methods from different disciplines be merged. Many of the most interesting and important problems in science can be answered only through collaborative efforts. It is crucial for students to understand the importance of having strengths in multiple disciplines. In this laboratory, students will extract DNA from strawberries using chemical and physical techniques, characterize the DNA using optical methods, and discuss the interrelation between biology, chemistry, and physics. In addition, this laboratory can be used in conjunction with "The Immortal Life of Henrietta Lacks" by Rebecca Skloot, a widely used college "one read" book choice. This relationship between science and literature further addresses the need for students to be proficient in reading and writing while covering discipline specific content.

DC11: 09:30-10:30 a.m. The Physics of Human Performance: An IDEAL Lab

Poster – W. Blake Laing, Southern Adventist University, PO Box 370, Collegedale, TN 37315, LAING@SOUTHERN.EDU

Harold Mayer, Southern Adventist University

Physics lab goes to the gymnasium, where students calculate the mechanical power required to walk on an inclined treadmill in watts and convert to units power used to measure human performance: VO2, and METs. Students learn how to use two linear regression models: the ACSM "walking equation" to estimate the actual power expenditure of walking and the Rockport 1 mile test to estimate their own VO2max. Students use models to prescribe exercise parameters for themselves and for two cases. The IDEAL lab collaboration is developing labs that are open, applied to life, and rigorously quantitative.

DC12: 9:30-10:30 a.m. Towards Authentic Problem-solving for the Pre-health Student in Introductory Physics

Poster – Nancy Beverly, Mercy College, School of Health and Natural Sciences, Dobbs Ferry, NY 10522; nbeverly@mercy.edu

What problem-solving skills do pre-med, pre-dent, pre-vet, or pre-PT students really need that physics can uniquely strengthen and support? Diagnosis and treatment planning requires asking questions, deciding what tests to give, looking for underlying causes, making a treatment plan based on a model of disease or condition, and evaluating the effectiveness of the treatment. Mimicking that approach, students at Mercy College now pose their own biomedical questions then reframe it in terms of an underlying physical mechanism. They determine the physical principles of an essential feature of the functioning and choose a model clarifying the relationships of the quantities involved, from which a calculated result may provide insight or allow making an inference to the larger question. They determine what information is needed, then measure, find, or estimate it, do the calculation, and then evaluate the significance and meaning of the result, including addressing limitations of the model.

DC14: 9:30-10:30 a.m. Design Your Own Physics Text

Poster – Donald G. Franklin, Spelman College, Penfield College of Mercer University, 39 West Main St., Hampton, GA 30228; dgfrank1@aol.com

Using Openstax.college you can emphasize the topics your students need rather than Chapters 1 to where ever you finish the semester or year. Also, you have other ebooks you can use to show how physics is related to all sciences.

DC15: 9:30-10:30 a.m. Transforming the Introductory Physics for the Life Sciences (IPLS) Course at a Liberal Arts Primarily Undergraduate Institution

Poster – Patricia Soto, Creighton University, 2500 California Plaza, Omaha, NE 68178-0001; PatriciaSoto@creighton.edu

Gintaras Duda, Michael G. Cherney, David L. Sidebottom, Creighton University

Creighton University is a private, coeducational and liberal arts PUI recognized in the Midwest as an institution with strong pre-health programs, including pre-medicine. The physics department strives to provide an educational experience that fulfills the current demands of life scientists, in line with the Jesuit mission of the institution. In the IPLS course, instructors use active learning techniques and focus on physics foundational principles to model quantitatively biological processes at the micro- and macro-scale. The course emphasizes numerical, graphical, and verbal representation of the life mechanisms under study, both in lecture and in a standalone laboratory course. In addition, students develop meta-cognitive self-monitoring skills through guided personal reflections; to help them develop ownership of their learning process and commit to effective study habits. We will discuss the sustainability and strengths of our course development, and provide examples of lecture and lab materials.

Session DD: Coordinating Outreach with Community Science Centers

Location: SSU - Charles Carroll B
Sponsor: Committee on Science Education for the Public
Date: Tuesday, July 28
Time: 8:30–9:40 a.m.

Presider: Stanley Micklavzina

DD01: 8:30-9 a.m. Outreach Opportunities Thorough Your Local Science Museum

Invited – Samuel Sampere, Syracuse University, Department of Physics, 201 Physics Building, Syracuse, NY 13244; smsamper@syr.edu

Peter Plumley, Museum of Science and Technology

I once heard a talk by Nobel laureate Doug Osheroff. He described how he became the black sheep of his family of medical doctors, and instead became a physicist. The turning point for him was experiencing a mobile science exhibit as a kid. Local science centers will typically bend over backwards to have scientists and teachers interact with their staff and visitors. Numerous opportunities may already exist, or you may need to create your own. I will share some of my experiences creating a permanent cosmology exhibit, and working with them on their own projects as well. These are very rewarding and fulfilling experiences. At the very least, you can perhaps foster an interest in science in some museum visitor or educate a voter. But maybe... your interaction with some kid will yield a future laureate!

DD02: 9-9:30 a.m. LIGO Livingston LA Science Education Center Partnership with Southern University

Invited – Kathy Holt, LIGO LLO Science Education Center, 19100 LIGO Lane, PO Box 940, Livingston, LA 70754; kholt@ligo-la.caltech.edu

Luria Young, Southern University and A&M College

William Katzman, LIGO-LLO Science Education Center

LIGO Science Education Center, an informal science center, in Livingston, LA, is in partnership with Southern University and A&M College, a formal education institution and historically black college and university in Baton Rouge, LA. A goal of the partnership is to strengthen the training and research of STEM and education undergraduate students through an initiative known as Docent Training Program. Students are recruited by both LIGO and Southern University and trained at the LIGO Science Education Center. The training takes place in the summer with LIGO and The Science Exploratorium staff. Trained docents work with LIGO SEC staff during the academic year to facilitate field trips for PK-12+ students, support during STEM School nights and public outreach. We will share our successes and challenges over the last eight years. We hope to inspire other informal science centers and formal educational institutions to use our model to develop a similar program.

DD03: 9:30-9:40 a.m. NASA Aeronautics Resources for Introductory Physics Students

Contributed – Rebecca E. Vieyra, Triangle Coalition for STEM Education - Einstein Fellow placed at NASA Aeronautics, 300 E St. SW, Washington, DC 20546; rebecca.e.vieyra@nasa.gov

Learn about resources for introductory physics students (high school to college graduate education) through NASA Aeronautics Scholarships for research opportunities, funding, and internships at NASA centers. Additional resources for teaching fundamental physics through aeronautics in introductory physics will be made available, including modeling-friendly lessons and labs that have been developed from published articles in The Physics Teacher and then reviewed and revised by AAPT members.

Information for accessing NASA aeronautics videos, e-publications, web and app-based interactives and simulations, as well as other aeronautics learning tools will be presented.
*NASA Aeronautics: http://www.nasa.gov/topics/aeronautics/ NASA Aeronautics Scholarships: http://goo.gl/yKFFEc

Session DE: Finding Resources in History of Physics Suitable for Classroom Use

Location: SSU - Juan Ramon Jimenez
Sponsor: Committee on History and Philosophy in Physics
Co-Sponsor: Committee on the Interests of Senior Physicists
Date: Tuesday, July 28
Time: 8:30–10:10 a.m.

Presider: Ruth Howes

DE01: 8:30-9 a.m. Using Online Exhibits to Enrich Physics Teaching: The AIP History Center Web Exhibits

Invited – Teasel Muir-Harmony, American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843; tmuir@aip.org*

The Center for History of Physics at AIP boasts over a dozen online exhibits ranging in topic from the history of lasers to the discovery of the electron. This talk will introduce teachers to these multimedia sites and offer suggestions for various ways AIP's online exhibits can be utilized in the physics classroom. Online exhibits are a unique resource because they provide an interpretive framework for learning about a particular topic yet they are still open-ended, allowing users to dig deeper into areas in the history of the physical sciences that catch their interest. This flexibility, and the multiple levels of detail embedded in each site, also enables teachers to tailor these exhibits for specific classroom uses, for specific grade levels, or different learning styles. By focusing on one exhibit in particular, such as "Albert Einstein: Image and Impact," this talk will provide specific examples of how to draw on and incorporate AIP's online exhibits into physics curriculum.
*Sponsored by Gregory Good, American Institute of Physics

DE02: 9-9:30 a.m. Teaching a Diverse History of Physics: Women and African Americans in the Physical Sciences

Invited – Sharina J. Haynes, American Institute of Physics, One Physics Ellipse, College Park, MD 20740 sjhaynes10@gmail.com

Serina Hwang Jensen

Diversity in STEM fields continues to be an issue of great concern to the scientific community. One aspect of diversity that often goes unacknowledged is the place of women and minorities in the history of the physical sciences. While women and minorities have historically faced significant barriers to entering the sciences, there have also been those who have contributed greatly to scientific history. To uncover and promote these stories, the American Institute of Physics Center for the History of Physics established the Women and Minorities Project in 2012 to encourage educators in history and science to incorporate the stories of women and minority scientists into their classrooms. The project has resulted in the development of two teacher's guides on women and African Americans in the physical sciences. By featuring historical actors who challenge societal conceptions of who is a scientist, we hope that students will broaden their picture of what a scientist looks like and that women and minority students will find new role models that reflect their experiences. Through lesson plans, puzzles and games, handouts, annotated bibliographies, and lists of online resources, educators and students will learn about people like Katherine Johnson--the African-American woman who calculated the trajectory for the Apollo 11 mission, Edward Bouchet--the first African-American PhD in Physics (from Yale in 1876), and astronomer Jocelyn Bell, who detected the first evidence of a pulsar. The teacher's guide on African Americans also links to Common Core and Next Generation Science Standards, two sets of standards that are becoming increasingly important nationwide. We will introduce the Women and Minorities Project, discuss our strategies in developing the teacher's guides, and share our vision for how we hope the project will increase diversity in the physical sciences.

DE03: 9:30-10 a.m. Using Oral History in Teaching Physics

Invited – Gregory A. Good, American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843; ggood@aip.org

The history of any science, on close consideration, consists of the collection of the stories of the lives of scientists. At the American Institute of Physics, we have been collecting oral history interviews – letting scientists tell their stories – for over 50 years. We now have the transcripts of over 1000 oral history interviews on our web site http://www.aip.org/history-programs. We include interviews with physicists, astronomers, geophysicists, and more. We are also always making new interviews to tell the stories of more recent science. Our current projects include the stories of women and African Americans in the physical sciences, as well as projects on space science and NOAA's atmospheric science group. Opportunities exist, too, for students to do oral history interviews with relatives or others who may be scientists. This is an excellent way for students to discover the humanity of science and scientists.

DE04: 10-10:10 a.m. Nuclear Emulsions, Miss A and P-10

Contributed – Ruth H. Howes, Ball State University, 714 Agua Fria St., Santa Fe, NM 87501; rhowes@bsu.edu

The story of the calculators, a group of women who worked with Marchant Calculators to track the shock waves in the imploding core of a plutonium bomb is well known. After the war, electronic computers proved adept at such calculations. However, the state of the art in nuclear detection for accelerator experiments was stacks of glass plates coated with photographic emulsions. Los Alamos Scientific Laboratory needed to conduct studies of nuclear reactions. Thus they needed somebody to read the emulsions. This paper tells the story of the development of nuclear emulsions by Marietta Blau; the woman physicist who led the group of microscopists who read them, Alice Hall Armstrong, and the women microscopists who worked in P-10, the acronym for the group at Los Alamos.

Session DF: Interactions of Gender and STEM Environments

Location: SSU - Charles Carroll A
Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 28
Time: 8:30–10:20 a.m.

Presider: Jennifer Blue

DF01: 8:30-9 a.m. Beyond Representation: Data on Women's Careers in Physics*

*Invited – Rachel Ivie,** American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843; rivie@aip.org*

The number of women earning physics degrees is increasing, but the percentages remain low. Although the physics and astronomy communities commonly focus on increasing the representation of women, data from two American Institute of Physics studies show differences in areas that have real impact on women's careers regardless of their representation in the fields. For example, data from the Global Survey of Physicists show that women have access to fewer career-advancing opportunities and resources and that this slows career progress. These effects hold constant across a variety of countries. Results from another study, the Longitudinal Study of Astronomy Graduate Students, show several factors that increase women's likelihood of working outside the field. These include rating graduate advisors less favorably and having a "two-body" problem (needing two jobs in the same geographic area).
*Partially funded by NSF and Henry Luce Foundation. **Sponsored by Ramon Barthelemy

DF02: 9-9:30 a.m. Gender in PER: What's Been Done, How Should We Move Forward?

Invited – Jennifer Blue, Miami University - Oxford, 500 East Spring St., Kreger 217, Oxford, OH 45056; bluejm@muohio.edu

Ximena C. Cid, University of Washington

Much work has been done on gender in the PER community. Many of these works focus on gender difference in participation, performance and attitudes towards physics. There are three critiques of this work, 1) it does not question whether the performance of men is the most appropriate standard, 2) individual experiences and student identities are undervalued, and 3) the binary model of gender is not questioned. This talk will focus on a brief discussion on what has been covered in the literature base, regarding gender, a proposed conception of gender that is more up-to-date with other fields, and examples that highlight how individual identities are grounded in this new proposed conception of gender.

DF03: 9:30-10 a.m. Women's Persistence in Undergraduate Astronomy: The Roles of Support, Interest, and Capital

Invited – Melinda McCormick, Western Michigan University, 1903 W. Michigan Ave., Kalamazoo, MI 49008-5202; melinda.m.mccormick@wmich.edu

Ramon S. Barthelemy, Charles Henderson, Western Michigan University

This study uses data from qualitative interviews with successful female graduate students in astronomy to explore female student success in undergraduate physics departments. The data suggest that some of the aspects of Whitten et al.'s 2003 model of the loom were important for these female graduate students when they were undergraduates in astronomy. These aspects include the role of faculty support through an undergraduate's education, the provision of engaging introductory courses, the importance of community amongst students, and more. However, the results also suggest that there are other factors that influence the success of the students, such as a love of the field of study and available resources in terms of different types of capital. The authors argue that in order to increase numbers of female students in the field, these considerations also need to be addressed.

DF04: 10-10:10 a.m. Undergraduate Research Outcomes at Primarily Undergraduate Institutions – Does Gender Matter?

Contributed – Birgit Mellis, University of St. Thomas, Department of Chemistry & Physics, 3800 Montrose Blvd., Houston, TX 77006; mellisb@stthom.edu

Chrystal D. Bruce, Graciela Lacueva, John Carroll University

Patricia Soto, Creighton University

Anne M. Wilson, Butler University

For undergraduate students in the early stages of their scientific careers, one of the most important experiences in deciding whether to continue in STEM fields is participation in undergraduate research. The communication of research results via presentations or publications is a measure of the level of scientific engagement by undergraduate students. We collected data on the on-campus research experiences of nearly 800 undergraduate students in the STEM fields of physics and chemistry at four Primarily Undergraduate Institutions (PUIs) from 2004-2013 and analyzed them regarding the gender of research participants and their advisors, discipline of study, and research outcomes, i.e., in form of theses, presentations, and peer-reviewed publications. The effects of gender in the outcomes will be discussed.

DF05: 10:10-10:20 a.m. Effects of Workshop Group Gender Balance on Student Exam Performance

Contributed – Judy Hardy, University of Edinburgh, School of Physics and Astronomy, James Clerk Maxwell Building, Mayfield Rd., Edinburgh, EH9 3JZ UK; j.hardy@ed.ac.uk

Ross Galloway, Ross Hunter, University of Edinburgh

A number of studies have reported on the influence of gender balance in group-based teaching environments on student assessment performance. Inspired by the results presented by Andrew Duffy at the 2014 AAPT Summer Meeting, we have conducted an experimental intervention in our introductory physics class at the University of Edinburgh, UK. This is a calculus-based course at a large, research-intensive university, and is taught in a 'flipped classroom' format. The class consists of around 280 students, around a quarter of whom are female, and is taught in four workshop sections. Within the workshops, the students are seated in groups of five or six. We manipulated the seating arrangements (without highlighting our intentions to the students) such that in two of the sections, groups containing female students were either gender-balanced or contained more females than males ('balanced groups'). In the remaining two sections, groups were allocated randomly, such that there were typically only one or two female students per group ('random groups'). We investigated student performance in these grouping types, and found that female students in balanced groups outperform female students in random groups by nearly 10 percentage points in the final exam, a highly statistically significant result. Male students in the balanced groups also outperformed their randomized equivalents, but not to a statistically significant extent. Causation is difficult to unambiguously determine, but it appears that prior ability in physics, major/non-major status and country of origin of the students are insufficient to explain the observed differences in performance.

Session DG: Improving Students' Problem Solving, Reasoning, and Metacognitive Skills

Location: Jimenez Hall (JMZ) - 0105
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 28
Time: 8:30–10:30 a.m.

Presider: Chandralekha Singh

DG01: 8:30-9 a.m. Coaching Physics Problem Solving Emphasizing Metacognition: A Role for Computers*

Invited – Kenneth Heller, University of Minnesota, School of Physics & Astronomy, Minneapolis, MN 55455; heller@physics.umn.edu

Student problem solving is weak because it focuses on the specific and formulaic. Moving students toward seeing problem solving as a complex series of decisions requires explicit and concrete instruction. The weakest link in that instructional process is the insufficient amount of coaching time available. Modern personal computers linked to the Internet are available to students on demand and could provide a useful supplement to instructor and peer coaching. This requires software that follows a student's predilections while giving feedback about the decisions necessary to pursue that path. Although computer coaches are not as flexible as a good human coach, they have some advantages over humans: not only are they always available, they are infinitely patient and are perceived by students as being nonjudgmental. This talk illustrates the decisions required by introductory physics problem solving, shows features of computer coaches, gives data indicating their promise, and outlines a path forward.

*Work supported in part by NSF DUE 0715615 and 1226197 and the University of Minnesota.

DG02: 9-9:30 a.m. Role of Multiple Representations in Physics Problem Solving*

Invited – Alexandru Maries, University of Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15260; alm195@pitt.edu

Chandralekha Singh, University of Pittsburgh

Shih-Yin Lin

Physics experts use a wide variety of representations (diagrammatic, graphical, verbal, mathematical etc.) to represent physics concepts. In order to help students transition towards expertise in physics, instruction should, at least in part, improve students' facility with multiple representations of physics concepts. In order for instruction to be more effective in this regard, instructors and teaching assistants should be familiar with common student difficulties with commonly used representations of physics concepts. In this talk, I will present several research findings pertaining to use of representations in physics problem solving and discuss instructional implications.

*Work supported by the National Science Foundation

DG03: 9:30-10 a.m. Using Videogame Dynamics, Clickers, and Communities to Reframe Student Engagement

Invited – Ian D. Beatty, University of North Carolina at Greensboro, PO Box 26170, Greensboro, NC 27402-6170; idbeatty@uncg.edu

William J. Gerace, University of North Carolina at Greensboro

The most important variable in student learning is how students engage in the learning process. Using sound, research-based curricula and active-learning techniques is important, but only to the degree that students engage with these things earnestly and constructively. We can induce more students to "invest" themselves fully in their learning, and to bring a more fruitful set of cognitive and metacognitive resources to bear, by "changing the game" to challenge their preconceptions and cause them to re-frame their goals and activity. At UNCG, we have used three specific strategies to accomplish this: clicker and whiteboard questions that foreground process and inventiveness rather than knowledge and correctness, courses rebuilt from the ground up to mimic the learning dynamic of videogames, and discipline-focused learning communities that promote professional identity formation and frequent introspection.

DG04: 10-10:30 a.m. Different Majors' Attitudes Toward Problem Solving: What Factors Matter?

Invited – Andrew Mason, University of Central Arkansas, Lewis Science Center, 171 Conway, AR 72035-0001; ajmason@uca.edu

A recent trend to designate introductory physics for life science (IPLS) courses seeks to address a large need among life science and health science majors. However, many physics departments frequently must treat these student major populations alongside physical science, computer science, and non-science majors. As such, students may differ on attitudes towards physics as their needs from the course may be related to requirements from a different department, and in some cases an entirely different college within the university, than a department of physics and astronomy. An investigation in an introductory algebra-based physics course with the aforementioned population suggested a possible connection between students' views of a laboratory-based metacognitive problem solving exercise and their choice of major, attitudes towards physics, conceptual understanding, and overall course grade. We discuss follow-up analysis of two class sections that differ significantly from each other in population by major and pre-test scores.

Session DH: Mentoring and Induction of Entering Physics Teachers

Location: Jimenez Hall (JMZ) - 0220
Sponsor: Committee on Teacher Preparation
Date: Tuesday, July 28
Time: 8:30–10 a.m.

Presider: Shane Wood

DH01: 8:30-9 a.m. Mentoring the Entering Physics Teacher, from a Student to Teacher

Invited – Duane B. Merrell, Brigham Young University, N-143 Eyring Science Center, Provo, UT 84602; duane_merrell@byu.edu

In the past 11 years Brigham Young University has had an opportunity to work with over 120 students prepared and certified to teach secondary physics. If we have a secret to our success it will be shared in this session, (we don't—except for our student's). The effort for mentoring the students throughout the preparation program, through student teaching and into the first years of teaching will be the highlight of the talk. Where and when do we find the students who need the most mentoring and can we as the university provide that help.

DH02: 9-9:30 a.m. Mentoring Future Physics Teachers at the University of Wisconsin - La Crosse*

Invited – Jennifer L. Docktor, University of Wisconsin - La Crosse, Department of Physics, 1725 State St., La Crosse, WI 54601; jdocktor@uwlax.edu

How can we provide future physics teachers with appropriate advising, coursework, and experiences to be successful in their future classrooms? How can we mentor students during their teacher preparation program and extend that mentoring beyond graduation? I will describe recent changes that have been made to the secondary teacher education preparation program at the University of Wisconsin – La Crosse to provide teacher candidates with focused mentoring and opportunities for early teaching experiences. I will also describe how the Physics Department has established partnerships with local schools by holding professional development workshops for practicing teachers.

*This material is based on work supported by the Physics Teacher Education Coalition (PhysTEC) and the National Science Foundation under Grant No. 0808790, 0108787, and 0833210.

DH03: 9:30-9:40 a.m. Insight of a First Year Teacher: Reflections on the Mentee Experience

Contributed – Jessica M. Lang, Cambridge High School, 2845 Bethany Bend, Milton, GA 30004; Langj@fultonschools.org

Rebecca S. Howell, Lambert High School

This presentation is the insight of a first year teacher on the mentee experience. The focus will be on the qualities of a functional mentor/mentee relationship and the effect of such a relationship on a new teachers first year experience.

DH04: 9:40-9:50 a.m. Reflections of a Master Teaching Fellow: Kennesaw State University, I-IMPACT

Contributed – Rebecca S. Howell, Lambert High School, 804 Nichols Rd., Suwanee, GA 30042; Rhowell@forsyth.k12.ga.us

David Rosengrant, Kennesaw State University

Meghan Lang, Lambert High School

I-IMPACT: Initiative to Increase and Mentor Physics And Chemistry Teachers is a selective program funded by a Robert Noyce award from the National Science Foundation. This presentation is the reflections of a Master Teacher Fellow's experience as a mentor. The focus will be on how leadership and relationships are essential for positive and productive mentee/mentor interactions.

DH05: 9:50-10 a.m. Physics Teachers Summer Academy at Buffalo State College

Contributed – David Abbott, 304 Stillwell, Kenmore, NY 14217; abbottds@buffalostate.edu

Dan MacIsaac, Buffalo State College

At Buffalo State College, the physics department runs several courses for prospective and practicing physics teachers, collectively called the Physics Teachers Summer Academy. The Summer Academy serves practicing non-physics teachers seeking certification in physics (cross certification) and prospective teachers with backgrounds in physics seeking initial certification (alternative certification), including Noyce scholarship recipients. This talk will describe the courses, our clientele and examine the impact these courses have on the participants, including new physics teachers.

Session DI: PER: Diverse Investigations II

Location: John S. Toll Physics Building (PHY) - 1410
Sponsor: AAPT
Date: Tuesday, July 28
Time: 8:30–10:10 a.m.

Presider: Ben Zwicki

DI01: 8:30-8:40 a.m. Access to and Awareness of Undergraduate Research Opportunities at a Large Research University

Contributed – Stephanie Hanshaw, University of Colorado, Boulder, 65 Violet Ct., Ridgway, CO 81432; stephanie.hanshaw@colorado.edu

Heather Lewandowski, University of Colorado Boulder

The American Physical Society released a 2014 statement calling on all university physics and astronomy departments to provide all undergraduate students with access to research experiences. In response to this call, we investigated the current status of access to undergraduate research at CU-Boulder, a large research institution where the number of undergraduate physics majors outnumber faculty by more than five to one. We created and administered two surveys within CU-Boulder's Physics Department: one probed undergraduate students' familiarity with and participation in research; the other probed faculty members' experiences mentoring undergraduate researchers. We present results from these surveys about access to undergraduate research within CU-Boulder's Physics Department.

DI02: 8:40-8:50 a.m. Connecting the Reformed Dots: The Role that Summer Programs Play

Contributed – Hagit Kornreich-Leshem, Florida International University, 11200 SW 8 St., Miami, FL 33199; hkornrei@fiu.edu

Eric Brewe, Laird Kramer, Zahra Hazari, Goeff Potvin, Florida International University

FIU has implemented a three-pronged retention approach that aims to create connections between typically isolated PER-driven reformed elements namely, a Bridge summer program, reformed introductory STEM classes and the Learning Assistant Program. We identify impacts of the summer Bridge program on student performance, retention rate, academic progress and performance in mathematics courses by comparing to a similar group of FTIC (First-time-in-college) engineering freshmen who haven't participated in the program. Bridge students had higher retention rates than all other FTIC Engineering students, higher average cumulative credit counts and GPA, and outperformed all other engineering students as determined by their overall GPA in their mathematics courses. While this effect is substantial, Propensity Score Genetic Matching shows no effect on cumulative GPA when covariates such as high school GPA and SAT Math scores are included in the matched group of non-participants. We discuss these results in light of the involvement of the cohorts in the other reformed efforts.

DI03: 8:50-9 a.m. Implementing and Assessing Diverse Avenues of Student Support: The CSU S-STEM Program*

Contributed – Mel S. Sabella, Chicago State University, Department of Chemistry and Physics, 9501 S. King Dr., Chicago, IL 60628; msabella@csu.edu

Kristy Mardis, Chicago State University

The CSU S-STEM Program supported by the National Science Foundation seeks to increase the educational attainment of CSU students and encourage more students to think of themselves as scientists. Chemistry and physics majors in the S-STEM Program receive tuition support at CSU, engage in a summer program based on the University of California-Berkeley Compass Project, participate in early research experiences during their first year at CSU, and engage in a peer and faculty mentoring program. Students also receive funding to support travel to attend conferences and present research and explore graduate programs, teaching careers, and careers in scientific research. An emphasis on the development of community, in addition to academic and scientific support, are essential elements of the CSU S-STEM Program and build on the resources of our students who mainly come from neighborhoods on the southside of Chicago.

* Supported by the National Science Foundation (DUE #1356523); Roth, N.; Gandhi, P.; Lee, G.; Corbo, J. The Compass Project: Charting a New Course in Physics Education. *Physics Today* [Online] 2013.

DI04: 9-9:10 a.m. Assessing the Maryland Learning Assistant Program

Contributed – Chandra Anne Turpen, University of Maryland, 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu

Erin R. Sohr, University of Maryland, College Park

This presentation gives an overview of findings from the first four years of running a Learning Assistant (LA) program[1] at the University of Maryland, College Park (UMCP). At UMCP, LAs have supported educational transformation efforts across 12 different science courses and engaged 22 different instructors in research-based educational practices. In assessing the impact of this program on LAs, we have replicated CU-Boulder's finding that LAs' conceptual understanding is improved through participation in the LA program (~10% average absolute gain on FMCE[[2]]). [3] We are investigating the longitudinal impacts of the LA experience on LAs and how LA programs may be cultivating change agents. We find that many of our former LAs continue to be involved in some teaching and work to change how learning environments are structured. LAs also report that their experiences in the program were transformative for the ways that they thought about teaching and learning science.

1. V. Otero, N. Finkelstein, R. McCray, and S. Pollock (2006). "Who is responsible for preparing science teachers?" Science, 313, pp. 445-446. 2. R. K. Thornton and D. R. Sokoloff (1998). "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. of Phys.*, **66**(4), pp. 338-352.
3. V. Otero, S. Pollock and N. Finkelstein (2010). "A physics department's role in preparing physics teachers: The Colorado learning assistant model." *Am. J. of Phys.*, **78**(11), pp. 1218-1224.

DI05: 9:10-9:20 a.m. Learning Assistant Identity Development: Is One Semester Enough?

Contributed – Jessica Conn, Texas State University, 601 University Blvd., San Marcos, TX 78666-4615; jmc225@txstate.edu

Eleanor W. Close, Hunter G. Close, Texas State University

The physics department at Texas State University has had a Learning Assistant (LA) program in place for three years, supporting reform-based instructional changes in all sections of our introductory course sequence for majors. We are interested in how participation in the LA program influences LAs' identity as physics students and instructors; we have previously reported trends in increased community involvement and a shift in experienced LAs' concepts of what it means to be competent. Our interview data now include first-semester LAs, and we see a significant difference in physics identity development between these LAs and those with more experience. During their first semester, LAs seem to experience a state of unease with respect to teaching and learning. We explain this discomfort in terms of Piagetian disequilibrium around their conceptions of competence in teaching and learning, and examine evidence of their (re-)construction of identities of competence.

DI06: 9:20-9:30 a.m. Students' Reasoning About the Responsibilities of Scientists and Engineers*

Contributed – Ayush Gupta, University of Maryland, Room 1320 Toll Physics Building, College Park, MD 20742; Maryland ayush@umd.edu

Andrew Elby, Michelle Porcelli, University of Maryland, College Park

Thomas Phillip, University of California, Los Angeles

Courses in science/engineering ethics as well as research on students' developing sense of ethics often emphasize the micro-ethics of research, mentoring, and publications. Little research or instruction focuses on how future scientists/engineers understand the social, ethical, environmental, economic, and political impact of their scientific and technological contributions. Towards addressing this gap in literature, we are creating case-study accounts of how future scientists/engineers think about their responsibility towards the social impact of their contribution. The case studies draw from video-taped semi-structured interviews. Our preliminary analysis suggests that how some students construe a scientist's/engineer's responsibility depends not just on rationalistic moral reasoning and personal experiences, but on the particular issue at hand (weaponized drones versus bridges, for example), on their sense of self as a future engineer, views about what is engineering, sense of nationality, emotions, targets of empathy, and ideologies/narratives available to them through participation in the world at large.

*Work supported by NSF 1338700

DI07: 9:30-9:40 a.m. Mixed-Reality "Flight Simulator" for Physics Teaching: TLE TeachLivE™*

Contributed – Jacquelyn J. Chini, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816; jacquelyn.chini@ucf.edu

Kevin H. Thomas, Carrie Straub, University of Central Florida

TLE TeachLivE™ is a mixed-reality classroom that allows participants (typically K-12 pre-service or in-service teachers) to practice teaching with simulated students. Similar to a flight simulator for pilots, TeachLivE™ allows teachers to refine their skills without risk to real students, and to practice the same skills in the same instructional context several times. Here, we describe the use of TeachLive™ with a class of physics Learning Assistants (LAs). Each LA led a short discussion in the mixed-reality class, observed the other LAs lead discussions, and reflected with their teammates about the experience. After reflection, each LA re-taught the same discussion. Finally, LAs were asked to write about what they learned from their experience. We will focus on changes in their use of certain pedagogical skills, such as questioning, from their first to second interaction with the simulator as well as their reactions to the experiences.

*This work supported in part by NSF Grant Nos. 0808790, 0108787, and 0833210.

DI08: 9:40-9:50 a.m. Researching Ourselves: How Are We Helping Faculty to Change their Teaching?

Contributed – Alice Olmstead, University of Maryland, Department of Astronomy, 1113 Physical Sciences Complex Bldg., 415 College Park, MD 20742-2421 aolmstead@astro.umd.edu

Chandra Turpen, University of Maryland-College Park

Edward E. Prather, University of Arizona; Steward Observatory

Faculty professional development (PD) workshops are a primary mechanism used to increase the adoption and adaptation of research-based instructional strategies (RBIS). PD workshops draw in many physics and astronomy instructors and serve a critical role in changing instructional practices within our community. Our research focuses on two of the largest and longest-running workshops for faculty: the New Physics and Astronomy Faculty Workshop and the Center for Astronomy Education Teaching Excellence Workshop. We are developing a real-time professional development observation tool to document what happens during workshops. We reveal opportunities to improve these PD efforts through increased awareness of instructors' experiences and prior knowledge. We assume that all instructors have some pedagogical ideas that align with education research results, their "productive resources." We analyze interviews to demonstrate the nature of these resources and consider how different PD practices create different opportunities for instructors' resources to be built on.

DI09: 10-10:10 a.m. Characterizing Noyce Scholars Physics Classrooms Using RTOP

Contributed - Joseph L. Zawicki, SUNY Buffalo State,1300 Elmwood Ave., Buffalo, NY 14222; zawickjl@buffalostate.edu

Kathleen Falconer, Dan MacIsaac, Catherine Lange, Griffin Harmon SUNY Buffalo State

The Robert Noyce Teacher Scholarship Program was initially authorized in 2002. SUNY Buffalo State initially received Noyce funding in 2004. There have been approximately 40 scholars in Phase 1 and 26 scholars in Phase 2. Fifteen of these scholars were physics concentrations. Of these 15, four scholars are currently teaching physics or physical science in New York state. Another six scholars are currently in education, but not necessarily teaching physics or are not in the New York area. Of the remaining scholars, two have not yet completed the program. The selected Noyce physics scholars were observed, in the spring of 2015 semester, using the Reformed Teaching Observation Protocol (RTOP). Each scholar was observed several times; the observations were pre-arranged with paired observers. The resulting scores, with sub-scores, will be reported along with inter-rater reliability data. This data is a sub-set of a larger study of Noyce Scholars at Buffalo State.

Session DJ: Physics Education Policy (Panel)

Location: John S. Toll Physics Building (PHY) - 1412
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Science Education for the Public
Date: Tuesday, July 28
Time: 8:30–10 a.m.

Presider: Scott Franklin

This panel session will discuss public policy issues concerning physics education and prepare participants for a Congressional visit.

DJ01: 8:30-10 a.m. Policy Matters: Perspectives and Prospects in Educational Policy for Physics & Physics Educators

Panel – Noah Finkelstein, UCB 390, Department of Physics, Boulder, CO 80309; finkelsn@colorado.edu

National, perhaps unprecedented, attention is now being paid to science, technology, engineering, and mathematics (STEM) education. This attention includes calls for better education of more students and including broader segments of our society in STEM fields. At the same time, national moves are challenging the worth and value of higher education and even the need for physics education. This talk reviews the current landscape education policy, challenges and opportunities facing physics and higher education, and why physics and physicists in particular have been and must be involved.

DJ02: 8:30-10 a.m. Engagement in Policy Discussions During Difficult Fiscal and Political Times

Panel – Aline D. McNaull, American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843; amcnaull@aip.org

Informing policymakers about physics education policy involves being able to educate and discuss with non-scientists the importance of funding, regulations, and other issues that affect science. Policy decisions relating to physics education are increasingly becoming imbedded in political decisions. Physics and physics education funding are weighed against funding for social programs, medical research, and other issues. This session will address current topics in physics education policy and will provide examples of how the physics education community can effectively weigh in on policy decisions in order to advocate for scarce resources. While Congress continues to address issues relating to teacher training, professional development, retention, and assessment, the physics community has an opportunity to engage with policymakers to ensure that students have access to high-quality physics instruction. This session will provide information on current legislative actions and will provide tools to be able to engage in these discussions.

DJ03: 8:30-10 a.m. Policy Matters: Current Topics in STEM Education Policy

Panel – Tyler Glembo, 529 14th St NW, Suite 1050, Washington, DC 20045; glembo@aps.org

The role of the federal government in education is a hotly debated topic in Congress, causing education to become deeply embedded in politics. Federal funding of education, although covering only about 10 percent of total cost, has large impact in the classroom, from testing standards to low interest student loans. This talk will examine the current landscape in physics education including issues facing the community at a national/federal level and also legislation such as the Elementary and Secondary Education Act. We will also examine how stakeholders can develop effective messages and participate in discussions with policy makers.

Session DK: Succeeding as a Solo Physics Education Researcher (Panel)

Location: Art-Sociology Building (ASY) - 2203
Sponsor: Committee on Professional Concerns
Date: Tuesday, July 28
Time: 8:30–10 a.m.

Presider: Laura McCullough

Panel discussion on how solo PER folks can succeed at research while being the only PER person at their institution.

Panelists:

Steven Maier, Northwestern Oklahoma State University

DJ Wagner, Grove City College

Scott Bonham, Western Kentucky University

Beth Thacker, Texas Tech University

Session DL: Upper Division Undergraduate Courses and Labs

Location: Art-Sociology Building (ASY) - 2309
Sponsor: AAPT
Date: Tuesday, July 28
Time: 8:30–10:10 a.m.

Presider: Dianne Phillips

DL01: 8:30-8:40 a.m. Correlating Students' Beliefs About Experimental Physics with Laboratory Course Success

Contributed – Bethany R. Wilcox, University of Colorado at Boulder, 2510 Taft Dr. #213, Boulder, CO 80302; Bethany.Wilcox@colorado.edu

Doyle H. Woody, Dimitri Dounas-Frazer, Heather J. Lewandowski, University of Colorado at Boulder

Student learning in instructional physics labs is a growing area of research that includes studies exploring students' beliefs and expectations about experimental physics. To directly probe students' epistemologies about experimental physics and support broader lab transformation efforts at the University of Colorado Boulder (CU), we developed the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS). Previous work focused on establishing the accuracy and clarity of the instrument through student interviews and preliminary testing. Ongoing validation efforts include establishing the extent to which student epistemologies as measured by E-CLASS align with other measures of student learning outcomes (e.g., course grades). Here, we report on the correlations between final course grades and E-CLASS scores from two semesters of introductory and upper-division labs at CU and discuss implications for the validity of the E-CLASS instrument.

DL02: 8:40-8:50 a.m. The Role of Metacognition in Troubleshooting in Upper-division Electronics Courses*

Contributed – Kevin L. Van De Bogart, University of Maine, 120 Bennet Hall, Orono, ME 04469; kevin.vandebogart@maine.edu

MacKenzie R. Stetzer, University of Maine

As part of an ongoing effort to assess and promote student metacognition in physics, we have been examining student metacognitive abilities in the context of upper-division laboratory courses on analog electronics. While there are many important goals of laboratory instruction, particularly in upper-division courses, relatively little work to date has focused on investigation of how students in such courses troubleshoot malfunctioning circuits. In collaboration with researchers at the University of Colorado, we have been conducting think-aloud interviews with pairs of students as they attempt to troubleshoot a basic operational-amplifier circuit. Video data were analyzed in order to examine the relationship between the troubleshooting strategies employed by students and the metacognitive behaviors they exhibited (e.g., planning, monitoring, and evaluating). Preliminary results will be presented and implications for instruction will be discussed.

*This work has been supported in part by the National Science Foundation under Grant Nos. DUE-1245313, DUE-1323426, and DUE-0962805.

DL03: 8:50-9 a.m. Challenges to Responsive Teaching at the Upper Division

Contributed – Deepa Nathamuni Chari, Kansas State University, Department of Physics, Manhattan, KS 66506; deepa.chari@phys.ksu.edu

Eleanor C. Sayre, Kansas State University

How do instructors' in-the-moment decisions affect students' engagement and learning? Responsive teaching is a philosophy of teaching in which instructors value the seeds of goodness in students' ideas, and promote students' agency in experimentation and problem solving. The nature of responsiveness is discipline-specific, though the philosophy is usually used in elementary schools and with pre-service teachers. We are interested in applying responsive teaching to math-intensive upper-division physics courses such as Electromagnetic Fields. Upper-division courses are more culturally constrained in content coverage than service classes, and teaching responsively at this level presents unique challenges. We pair classroom video and reflective interviews with the instructor to examine the effects of the instructor's in-the-moment decisions to attend to the substance of students' ideas. Some of the features of responsive teaching emerge intact; others do not.

DL04: 9-9:10 a.m. Troubleshooting in an Electronics Course and the Experimental Modeling Framework

Contributed – Dimitri R. Dounas-Frazer, University of Colorado Boulder, Department of Physics, UCB-0390, Boulder, CO 80309-0390; dimitri.dounasfrazer@colorado.edu

Noah Finkelstein, Heather J. Lewandowski, University of Colorado Boulder

Troubleshooting systems is an integral part of experimental physics in both research and instructional laboratory settings. The recently adopted AAPT Lab Guidelines identify student ability to troubleshoot as an important learning outcome for the undergraduate physics laboratory curriculum. The Experimental Modeling Framework—which describes physicists' use of mathematical and conceptual models when reasoning about experimental systems--is a useful lens through which to characterize the troubleshooting process and, ultimately, to inform educational activities that develop troubleshooting skills in physics. Junior-level electronics labs are an ideal context for studying students' troubleshooting abilities, due in part to the simplicity of the physical systems and models with which students interact and the ease with which components can be replaced. Using data collected in think-aloud interviews in which pairs of students successfully diagnose and repair a malfunctioning circuit, we describe the scope and limits of the Experimental Modeling Framework as it applies to troubleshooting.

DL05: 9:10-9:20 a.m. Implementing Student-Centered, Tutorial-based Statistical and Thermal Physics

Contributed – Masahiro Ishigami, University of Central Florida, 4000 Central Florida Blvd., PS 430, Orlando, FL 32816; ishigami@ucf.edu

Reducing lectures and increasing student interactions in classrooms have been shown to be effective in enhancing the learning gains in upper- division courses by Loverude (Cal State Fullerton), Thompson (Maine), Pollock (Colorado), and others. I have reduced lecturing to below 50% by using in-class worksheets/tutorials, based on previous activities developed by Loverude and Thompson, in a 14-week Statistical and Thermal Physics course. This interactive teaching mode supported by small group activities is found to generate high levels of student normalized learning gains and student satisfaction. I will present these quantitative results along with examples of worksheets developed for the selected concepts in Statistical Physics.

DL06: 9:20-9:30 a.m. ECOPHYSICS I

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

The importance of Ecophysics will be explained. During this new era of global climate change, it is necessary to update by adding a new chapter on Ecophysics for your new students in your new Thermodynamics course, so that we will face the new reality with some understanding.

DL07: 9:30-9:40 a.m. Magnetic Resonance in Undergraduate Quantum Mechanics

Contributed – Larry Engelhardt, Francis Marion University, PO Box 100547, Florence, SC 29501-0547; lengelhardt@fmarion.edu

Magnetic resonance (MR) is a standard topic that is introduced in undergraduate quantum mechanics books, but I find the standard methods of analysis to be very unsatisfying. MR involves an oscillating magnetic field, which gives rise to a time-dependent Hamiltonian. This Hamiltonian is typically introduced, and it is followed by complicated (hand-waving) approximations. The reason for this is that the time-dependent Hamiltonian gives rise to coupled ODEs that cannot be solved analytically. So why not solve these ODEs numerically??? I will show that this is easy to do and can provide a better understanding of the phenomenon of magnetic resonance.

DL08: 9:40-9:50 a.m. Acoustic Analogs of Quantum Chaos in the Undergraduate Laboratory

Contributed – Kevin Schultz, Hartwick College, PO Box 4020, Oneonta, NY 13820; NY schultzk@hartwick.edu

Alexa Dickerson, Samantha Malcolm, Hartwick College

The study of quantum systems, whose classical counterparts are chaotic, is called Quantum Chaology. In my talk I will describe quantum chaos and how we can measure its effects as well as describing the experimental realization of quantum graphs, which are an ideal test bed for investigating quantum chaos. By taking advantage of the fact that acoustic waves in a duct have the same mathematical form as the Schrödinger Equation, we can build an acoustic analog to a quantum graph, which allows for low-cost experiments. This is a project that undergraduates can participate in at almost all stages of their education. It helps students make connections in wave mechanics, classical mechanics, and quantum mechanics. The experimental setup is easy enough that none of it is a "black-box", yet the system is rich enough that there is room for the student to grow.

DL09: 9:50-10 a.m. Medical Imaging: Teaching About the Gamma Camera and Ultrasound Imaging

Contributed – Mary L. Lowe, Loyola University Maryland, Physics Department, 4501 N. Charles St., Baltimore, MD 21210; mlowe@loyola.edu

Alex Spiro, Loyola University Maryland

Ronald F. Vogel, Iowa Doppler Products

Noninvasive medical imaging techniques enable doctors to see inside the human body without having to make an incision. Two important techniques include the gamma camera and ultrasound imaging. After a radiopharmaceutical is introduced into a patient, gamma rays emitted by the radionuclide are detected by a gamma camera, which creates an image showing the spatial distribution of gamma emitters in the body. The image is useful for diagnosing disease. In ultrasound imaging a transducer produces ultrasonic pulses at various angles that are reflected from objects in the body and detected. The time between the pulse and the echo enable a distance to be determined and an image to be constructed. We are developing modules to teach upper division students the principles underlying these two techniques. Different apparatus help the students understand the physics, instrumentation, and software. The modules integrate medical case studies, prediction, hands-on activities, direct instruction, and problem solving.

DL10: 10-10:10 a.m. The Physics of the Thomson Jumping Ring Is Unveiled

Contributed – Celso Luis Ladera, Universidad Simón Bolívar, Valle de Sartenejas, Baruta, Edo. Miranda Caracas, 1086, Venezuela; clladera@usb.ve

Guillermo Donoso, Universidad Simón Bolívar

The rich physics behind the flight of the conducting ring in the well-known Thomson experiment is hard to see because of the fast thrust that impels the ring. Here we unveil interesting features of the electro-dynamics of this flying ring, e.g. the varying mutual inductance between the ring and the thrusting electromagnet, or even better the ring´s proper magnetic field in spite of the presence of the much larger field of the electromagnet. We introduce a comprehensive analytical model of the ring flight, and a low-cost jumping ring set-up that incorporates simple innovative devices, e.g. a couple of pickup coils connected in opposition that allows us to scrutinize the ring electro-dynamics, and accurately confirm the predictions of our theoretical model. This work is within the reach of senior students of physics or engineering, and it can be implemented either as a teaching laboratory experiment or as an open-ended project work.

Awards Session: 2015 Fellows Recognition; 2015 Klopsteg Memorial Lecture Award: David Weintraub

Location: SSU - Hoff Theater
Date: Tuesday, July 28
Time: 10:45 a.m.–12 p.m.

Presider: Steven Iona

The 2015 Fellowship recipients, selected from AAPT's Two-Year College community are:

- ***Frank Cascarano,*** *Foothill College, Los Altos Hills, CA*
- ***Anthony Escuadro,*** *Harold Washington College, Chicago, IL*
- ***Paul "Joe" Heafner,*** *Catawba Valley Community College, Hickory, NC*
- ***William Waggoner,*** *San Antonio College, San Antonio, TX*
- ***Paul Williams,*** *Austin Community College, Austin, TX*


David Weintraub

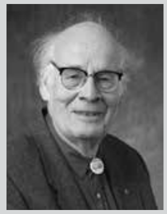
2015 Klopsteg Memorial Lecture Award

David Weintraub, Vanderbilt University, Department of Physics and Astronomy, Nashville, TN 37240; david.a.weintraub@Vanderbilt.Edu

Exoplanets: The Pace of Discovery and the Potential Impact on Humanity

Astronomers have now discovered thousands of planets in orbit around other stars. I will briefly describe how those discoveries have been made and predict the progress astronomers are likely to make in their studies of these planets over the next fifty years, as we begin to study these planets in detail. Then we will consider the consequences of those potential discoveries, which are likely to be profound. The twentieth century inventor and visionary Buckminster Fuller once said, "Sometimes I think we're alone. Sometimes I think we're not. In either case, the thought is staggering." Astronomers are on the cusp of discoveries that may be both profound and staggering, and we'd best be ready.

Session EA: Al Bartlett Memorial Session



Al Bartlett
1923–3013

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Science Education for the Public
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Amber Stuver

EA01: 1:30-3:30 p.m. Albert Allen Bartlett: An Extraordinary Career

Invited – Paul D. Beale, University of Colorado, Boulder, Department of Physics, 390 UCB, Boulder, CO 80309-0390; paul.beale@colorado.edu

I was proud to have had Albert Allen Bartlett as a friend and colleague. During his remarkable career as a physicist, professor, and public servant, he had an extraordinary range of jobs: assistant night cook on an iron ore freighter on the Great Lakes, summa cum laude physics student at Colgate University, research physicist during WWII at Los Alamos, photographer of the atomic bomb test at Bikini Atoll, nuclear physics PhD graduate from Harvard University, renowned physics professor at the University of Colorado, community and environmental activist, and President of the American Association of Physics Teachers. I will try to distill Al's many accomplishments and impacts through reminiscences, his own and those of his family and friends.

EA02: 1:30-3:30 p.m. Can STEM Outreach be Physics Outreach?

Invited – Patricia Sievert, Northern Illinois University, STEM Outreach, Lowden Hall 307, DeKalb, IL 60115; psievert@niu.edu

Imagine walking into an arena and seeing 7500 kids and community members absolutely jazzed about being engaged in STEM learning through exhibits from across the STEM disciplines, including our Haunted Physics Lab, Laser Lab, and other interactive physics experiences. This is STEMfest, just one day of our amazing year of STEM programming for students, families, teachers, and average citizens. Inspired by Al Bartlett, who committed decades of his life to increasing the public's understanding of the consequences of a single concept, exponential growth, NIU STEM Outreach has gone from an underfunded physics outreach program to share our love of physics through STEM with tens of thousands of participants annually from preschoolers to retirees, in schools, camps, libraries, pubs, parks, and music festivals. Come hear how we keep physics in STEM and learn what you might do to provide physics outreach opportunities in your community.

EA03: 1:30-3:30 p.m. Inclusion & Inconvenient Truths

Invited – Brian Jones, Colorado State University, Physics Department, Fort Collins, CO 80523; physicsjones@gmail.com

Al Bartlett was a feature of physics education in Colorado—and farther afield—for many years. He influenced many of us with his willingness to engage audiences at all levels, with his willingness to say things that many people would rather not hear. What are the lessons that we should be sharing now? And how do we best present them to different audiences?

EA04: 1:30-3:30 p.m. Dr. Al Bartlett's "Arithmetic, Population and Energy" Memorial Presentation

Invited – Roger B. Arnold, Applied Market Economics, 909 Bayridge Terr., Gaithersburg, MD 20878; rogerarnold@appliedmarketeconomics.com

This is an abbreviated version of "Arithmetic, Population and Energy: Sustainability 101", the celebrated one-hour lecture by renowned University of Colorado physics professor, Dr. Albert Allen "Al" Bartlett. Professor Bartlett gave his talk over 1,742 times in the United States and worldwide. He first gave the talk in September 1969, and subsequently presented it an average of once every 8.5 days for 36 years. His talk is based on his paper, "Forgotten Fundamentals of the Energy Crisis," originally published in the American Journal of Physics, and revised in the Journal of Geological Education. Professor Bartlett began his one-hour talk with the now famous statement, "The greatest shortcoming of the human race is our inability to understand the exponential function." Dr. Bartlett passed away on Sept. 7, 2013. The presentation is delivered by Roger Arnold as certified by the University of Colorado, Boulder, Environmental Center.

Session EB: Best of European and Middle East Projects

Location: SSU - Benjamin Banneker B
Sponsor: Committee on International Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Chandralekha Singh

EB01: 1:30-2 p.m. Construct and Compare: Modeling Randomness and Structure with Computational Tools*

Invited – Edit Yerushalmi, Weizmann Institute of Science, Department of Science Teaching, 234 Herzl St., Jerusalem, 96788 Israel; edit.yerushalmi@weizmann.ac.il

Nava Schulmann, Weizmann Institute of Science

Structure formation in chemical and biological systems is associated with the competition of interactions between system constituents and randomness due to thermal effects. As introduction to a program on structure formation, we engaged 10th graders in constructing computational models to study random motion in systems of many, non-interacting particles. Students compared their models to the macroscopic behavior measured in "randomness-dominated" phenomena such as diffusion and osmosis. The students discussed the transitional links between alternative models to justify in depth the random nature of the behaviour and experience the process of building an optimal model: choosing players and game rules consistent with physical approximations: A deterministic Molecular Dynamics model calculating all particle trajectories (solute and solvent), a semi–deterministic Langevin model (where only solute trajectories are calculated and the solvent effect is modeled by friction and stochastic forces) and a probabilistic model – random walk on a lattice involving only the solute.

*We acknowledge useful discussions with Samuel Safran, Ariel Steiner, Haim Edri and Ruth Chabay

EB02: 2-2:30 p.m. Learning Communities of Physics Teachers – The Israeli Experience

Invited – Bat-Sheva Eylon, The Science Teaching Department, Weizmann Institute of Science, Rehovot, 76100 Israel; b.eylon@weizmann.ac.il

Esther Bagno, Smadar Levy, Hana Berger, Esty Magen, The Science Teaching Department, Weizmann Institute of Science

A physics teaching team from WIS since 2011 has enacted learning communities of physics teachers. The project employs a "fan-model": The WIS team leads a community of "teacher-leaders" who operate learning communities spread all over Israel. About 25% of physics teachers in Israel, teaching 20,000 students, participate in 10 communities. The teachers meet once every two weeks for four hours throughout the year, sharing resources and discussing practice. They engage as learners in research-based teaching strategies and enact customized-versions in their classes. They discuss with peers teaching and learning, using an "evidence-based" approach. Research suggests that the teachers develop a strong sense of community, become more sensitive to their students' learning-challenges, deepen their physics knowledge, start to practice new instructional strategies and their teaching is more engaging. These findings cohere with students reports. Additional teachers request regional communities and there is minimal attrition. The rationale and the challenges will be elaborated.

EB03: 2:30-3 p.m. HOPE Horizons in Physics Education: A European Academic Network*

Invited – Nadine Witkowski, Université Pierre et Marie Curie, 4 place Jussieu, Paris, 75005 France; nadine.witkowski@upmc.fr

Ivan S. Ruddock, The University of Strathclyde

Marisa Michelini, University of Udine

HOPE—Horizons in Physics Education—is an academic network of partners from 37 European countries. The 71 full partners comprise 65 universities and six other bodies such as EPS and CERN; the 20 associated partners include APS, GIREP, IOP and universities from North and South America. HOPE (http://hopenetwork.eu/) is funded within the Life Long Learning Programme of the European Union for three years from October 2013. With an overall aim of studying and researching the impact of physics higher education in Europe, the network focuses on four themes: factors influencing young people to pursue physics studies; physics graduates' competences that enable them to contribute to the needs of the European economy; the effectiveness and attractiveness of Europe's physics teaching and learning and its competitiveness in the global student market; strategies for increasing the supply of well-educated physics school teachers and for developing links between schools and universities.

*project n° 2013-3710_540130-LLP-1-2013-1-FR-ERASMUS-ENW Life Long Learning Programme of the European Union

EB04: 3-3:30 p.m. European Perspective on Learning Science in the Times of the Fast-changing World

Invited – Dagmara Sokolowska, Jagiellonian University, Lojasiewicza 11, Krakow, 30-348 Poland; ufdsokol@cyf-kr.edu.pl

Almost 10 years ago the European Commission issued recommendations on a renewed pedagogy of science for the future Europe. What has changed since then in curricula, everyday practice, and perception of teachers and learners? SECURE project has researched the current situation in 10 European countries, spanning the learners aged 5, 8, 11 and 13. The study revealed similarities and differences across countries and ages, finding at the same time the examples of exceptionally good practices that could be broadly implemented in order to enhance the sustainable change. One of the most striking student opinions expressed during SECURE interviews was that "there is science at school and (more interesting and attractive) science somewhere else". How can this discrepancy (if at all) be addressed in the classroom? Fibonacci project showed potential solution in a broad implementation of inquiry-based learning (IBL) activities. SAILS project enhanced feasibility of IBL by equipping the teachers with strategies for assessment of inquiry learning in science. The out-of-curricula alternative to motivate pupils to study science has been proposed in Firefly Contest for ages 6-12, showing that learners are ready for challenges in science that go well beyond the curricula.

Session EC: Best Practices in Educational Technology II

Location: SSU - Charles Carroll A
Sponsor: Committee on Educational Technologies
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Andy Gavrin

EC01: 1:30-1:40 p.m. HTML5 Simulations for Introductory Physics

Contributed – Andrew G. Duffy, Boston University, Department of Physics, 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu

The Java-based simulations that many of us have used in our teaching for years have effectively reached the end of their useful lives, because of security concerns. Simulations written in HTML5 and Javascript are a modern alternative, being able to be run both in browsers and on mobile devices. This talk will include some demonstrations of HTML5 simulations that are appropriate for use in introductory physics.

EC02: 1:40-1:50 p.m. Designing Interactive Simulations to Enhance Student Engagement

Contributed – Antje Kohnle, University of St. Andrews, North Haugh, St. Andrews, KY16 9SS, United Kingdom; ak81@st-andrews.ac.uk

Carl Humphreys, University of St. Andrews

Mark Paetkau, Thompson Rivers University

The QuVis Quantum Mechanics Visualization project (www.st-andrews.ac.uk/physics/quvis) consists of research-based interactive simulations for the learning and teaching of quantum mechanics. Recent work has focused on enhancing student engagement with the simulations through the inclusion of game-like elements. We have incorporated goal-and-reward structures using multiple challenges aligned with the learning goals of the simulations, and carried out studies to assess what factors impact students' engagement with the simulations. We have investigated the effect of the revised simulation elements on students' experience and time-on-task through individual student interviews and in-class trials in introductory and upper-division quantum mechanics courses. Factors impacting student engagement include interactivity, clearly defined goals, rewarding progress, real-world applications and on-demand explanations.

EC03: 1:50-2 p.m. Implementing Google Classroom and Google Tools Using iPads in a Physics Classroom

Contributed – James Flakker, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08903; jim.flakker@gse.rutgers.edu

Eugenia Etkina, Rutgers University

Finding new ways to implement technology can be challenging and may cause us to lose focus and stray from our original goals. Adding technology for the sake of having technology cannot be our motivation. Instead we need to find ways to use technology to improve our workflow and make us more responsive. We will discuss how Google Classroom, Google Tools and a 1:1 iPad initiative has changed the way the first author interacts with his high school students providing more detailed, real-time feedback for written work.

EC04: 2-2:10 p.m. With Physics to Everywhere: Experiments Using Your Smartphone

Contributed – Arturo C. Marti, Physics Institute, Universidad de la República Iguá, 4225 Montevideo, Montevideo, 11400 Uruguay; marti@fisica.edu.uy

Cecilia Stari, Cecilia Cabeza, Physics Institute, Universidad de la República

Martin C. Monteiro, Universidad ORT Uruguay

Smartphone usage has expanded dramatically in recent years. According to press releases one billion smartphones were sold in 2013 worldwide. The use of smartphones goes considerably beyond the original purpose of talking on the phone. Indeed, it is everyday more frequent to use smartphones as clocks, cameras, agendas, music players or gps. More remarkable is the habit, especially among young people, of bringing their phones every time and everywhere. From a physicist's point of view, it is impressive that smartphones usually incorporate several sensors, including accelerometers, gyroscopes, and magnetometers. Although these sensors are not supplied with educational intentions in mind, they can be employed in a wide range of physical experiments, especially in high school or undergraduate laboratories. Moreover, experiments with smartphones can be easily performed in non-traditional places as playgrounds, gyms, travel facilities, among many others. All the possibilities that smartphones exhibit, foster students interest in exploring, measuring and meeting the physical world around them.

EC05: 2:10-2:20 p.m. Using Online Interactive Learning Modules to Enhance Student Conceptual Learning

Contributed – Cheryl B. Davis, Brigham Young University, N215 ESC, Provo, UT 84602-0002; cheryl_davis@byu.edu

Robert C. Davis, Brigham Young University

A series of online interactive pre-class (50 modules) and pre-homework (20 modules) adaptive learning modules was developed and implemented with 500 introductory physics students at Brigham Young University this past year. These modules, which we call the Physics Guide, allow us to test the students' understanding of basic concepts before class and supplement, where needed, with short tutorials consisting of short screen-cast explanations and follow up questions. The primary goal of the pre-class Physics Guide is for students to arrive at class with a stronger more uniform background ready to engage in active classroom learning. We will present the response of students to our learning modules and the impact on conceptual exam scores for these students compared to students who took the class before these modules were used.

EC06: 2:20-2:30 p.m. Flipped Pedagogy with Lecture-Tutorials in Introductory Physics

Contributed – Enrique A. Gomez, Western Carolina University, Department of Chemistry and Physics, Cullowhee, NC 28723; egomez@email.wcu.edu

Laura Cruz, Yee Kao, Western Carolina University

We conducted a study of student responses to a flipped course of an introductory, algebra-based, college physics course. In this flipped course, content is presented in online videos on the Panopto platform introducing physics concepts and the subsequent classroom meeting time is dedicated to student centered activities such as Peer Instruction and Lecture-Tutorials. We collected student responses with three instruments: the Force Concept Inventory (FCI), the Colorado Learning Attitudes about Science Survey (CLASS), and a small group analysis. We compared this group to a control group subjected only to face-to-face lecture. We analyzed the shifts in student attitudes toward learning physics, the viewership curve of the videos throughout the semester, and the retention of force concepts at the end of the semester.

EC07: 2:30-2:40 p.m. Examining the Effect of Technology Usage on Multiple Physics Outcomes

Contributed – Jonathan V. Mahadeo, Florida International University, 1433 Banyan Way, Weston, FL 33327; jmaha001@fiu.edu

Zahra Hazari, Geoff Potvin, Florida International University

Technology has become more central to the teaching and learning of physics. These technologies include calculators, computer resources (e.g. simulations, online social networks, homework systems), and response systems (e.g. clickers). Drawing on data from a large scale national survey study with responses from 1955 students who had taken physics, we examined the effect of technology usage on students' physics identity, physics grades, and STEM career interest. Using Multivariate Matching, we compared groups who experienced or did not experience a particular technology and were matched on background. We found that high technological saturation had a significant positive effect on physics identity. Computer simulations had a positive effect on both physics identity and STEM career interest. Finally, science videos had a significant positive effect on physics grades but a negative effect on STEM career interest. We will discuss these results as well as supplementary qualitative data on how teachers use these technologies.

EC08: 2:40-2:50 p.m. Examining the Affordances of a Mobile-based Physical Science Curriculum for Teaching and Learning*

Contributed – Meera Chandrasekhar, University of Missouri, Physics Department, Columbia, MO 65211; meerac@missouri.edu

Deepika Menon,Troy A. Sadler, Dorina Kosztin, Douglas Steinhoff, University of Missouri

The purpose of this study is to investigate how affordances of mobile technology-based physical science (MOTEPS) curriculum can support pre-service elementary teachers in learning science and provide confidence in using mobile technologies in their own teaching. This study is guided by the assumption that there is limited evidence on ways in which mobile technologies support pre-service elementary teachers' learning and teaching science. The MOTEPS curriculum is available as an iPad application called "PhysicsFirst." It provides a range of affordances aimed to engage pre-service elementary teachers in learning science content as they develop the confidence to teach science using mobile technologies. This quasi-experimental, design-based research study is conducted in two sections of a specialized elementary physical science content course with 66 pre-service elementary teachers. The experimental group (N = 33) uses the MoTePS curriculum on an iPad and the comparison group (N = 33) uses a traditional workbook. Data sources include two surveys, which assess self-efficacy for teaching science with technology and demographic information, focus-group and individual interviews, weekly observations of the class and artifacts. Data analyses include both quantitative statistical procedures as well as grounded theory techniques to understand the affordances and constraints of MOTEPS curriculum. The preliminary results of this ongoing research will be presented. Findings will have implications for pre-service teacher preparation for future use of technology in science teaching.

*Supported by NSF DUE 0928924.

EC09: 2:50-3 p.m. Investigating Introductory Mechanics for Engineering and Life Science Students

Contributed – William R. Evans, University of Illinois at Urbana-Champaign, 303 Paddock Dr., West Apt. A1, Savoy, IL 61874; wevans2@illinois.edu

Mats A. Selen, University of Illinois at Urbana-Champaign

We report on a series of studies involving students both from the first-semester calculus-based mechanics course for physical science and engineering majors as well as from the first-semester algebra-based mechanics course which primarily serves life science majors. We compare these students with regards to a number of standard metrics including the CLASS, a series of physics concept questions, a series of mathematics skills questions, as well as a set of controlled clinical studies testing the effects of mastery-style homework on student learning.

EC10: 3-3:10 p.m. The S-Lab's Lab in a Box: A Potential Game Changer for Rural Schools in the Developing World

Contributed – Stephen J. Mecca, Providence College, 1 Cunningham Square, Providence, RI 02908; smecca@providence.edu

Megan Skrpek, Providence College & Columbia University

Elizabeth Degaray, Brittany Mandeville, Nicole Boyd, Michelle Feely, Jack Ricci, Delina Auciello, Kerry McIntyr, Providence College

The S-Lab's Lab-in-a-Box features a computer lab hosting a rich set of educational resources (the GSAP Portal) for Internet- and electricity-deprived schools. The first version of the portal being prototyped in Ghana includes the Rachel initiative on a 32-GB file set. The portal has been expanded to a 64-GB drive hosted on a Raspberry Pi server or directly on a PC or Laptop and its elements have been mapped to the Ghana school curriculum. The original powering option which consisted of solar collector and lead-acid battery was re-designed to eliminate the 12v-to-5v conversion making use of LiPo battery packs with significant improvements in energy, costs, weight and size. The system was also extended to bring science activities to the schools using available (Android) tablet sensors and instrument-analysis-reference-simulation- APPs. Small grants including an AAPT Bauder grant have enabled the addition of selected instruments complementing the resources of the package.

EC11: 3:10-3:20 p.m. Arouse the Student Interest of Physics from the Daily Life

Contributed – Xintu Cui, School of Physics and Engineering, Sun Yat-sen University, 135 Xingangxi Rd., Haizhu, District Guangzhou, 510275 China; stszfl@mail.sysu.edu.cn*

Han Shen, Fuli Zhao, Dihu Chen, Min Chen, School of Physics and Engineering, Sun Yat-sen University

We demonstrated a series of physics experiments related to our daily life to attract freshmen and the outstanding senior middle school students joining the physics research. The vibration experiment is one of these experiments. We designed the sound vibration experience through PASCO sensors and the pendulum measurements. After experiencing the experiment, the students were motivated to start the detail measurement of the pendulum and engaged themselves in the further analytical deduction of vibration equations such like damped oscillators. Acknowledgement: This work was supported by NSFC-J1103211, 1210034 and the Guangzhou Technology star for Teenagers. The authors thanks for the doctorate voluntary assistants Mingyuan Xie and Zebo Zheng.

*Sponsored by Fuli ZHAO **Acknowledgement: This work was supported by NSFC-J1103211, 1210034 and the Guangzhou Technology star for Teenagers. The authors thank the doctorate voluntary assistants Mingyuan Xie and Zebo Zheng.

EC12: 3:20-3:30 p.m. 3-D Demonstration Device Utilizing Circular Polarization

Contributed – Akshar K. Kumar, Loyola University Chicago, Department of Physics, 1032 W Sheridan Rd., Room 300, Cudahy Science Hall, Chicago, IL 60660; akumar6@luc.edu

Matthew R. Schmidt, Robert D. Polak, Loyola University Chicago

Modern 3D movies display different images intended for the left and right eye of the viewer by manipulating the image's light with circular polarization. The projected light reflects off a polarization maintaining screen and, with the use of passive glasses that only allow one circular polarization of light to pass through each eye, the brain creates a 3D image. We have developed a 3D demonstration piece where an additional phase shift is added to linear polarized light by a liquid crystal cell that is synched with two lasers to create left and right eye images. This demonstration allows for changing the time each image is shown; allowing the user to increase the frequency until the left and right eye images blur into a single image in the mind, as well as changing the laser position to allow the image to appear in front of the projection screen.

Session ED: Do You Want to Teach at a Community College?

Location: SSU - Charles Carroll B
Sponsor: Committee on Physics in Two-Year Colleges
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Scott Schultz

ED01: 1:30-2 p.m. Some Thoughts on Teaching at a Community College

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

Being a physics faculty member at a community college presents a number of challenges and opportunities. In this talk, I will discuss some of these which involve the dramatic growth of students taking physics at community colleges and the fairly large number of physics positions currently available at community colleges. Additionally, I will discuss why I have spent essentially my entire professional career at a community college and why I think you should too.

ED02: 2-2:30 p.m. What Are Two-Year Colleges Looking for in a New Hire?

Invited – Scott Schultz, Delta College, 1961 Delta Rd., University Center, MI 48710; sfschult@delta.edu

I have evaluated over 40 individuals seeking employment at Delta College, a two-year college in Mid-Michigan. I will share some of the qualities we are generally looking for and some of the questions that we use to help assess the candidate. I will share what teaching physics at our institution looks like and the job responsibilities associated with the position. Finally, I will talk about the support that is available to help new faculty fully embrace their role and become leaders of the next generation of skilled workers for this country.

ED03: 2:30-3 p.m. My Experiences Landing a Job at a Community College

Invited – Elizabeth Schoene, South Seattle College, 6000 16th Ave. SW, Seattle, WA 98106; elizabeth.schoene@seattlecolleges.edu

Several years ago I finished graduate school with a shiny new physics degree, but very little teaching experience. To my disappointment, I was woefully unprepared for the teaching career I had gone to graduate school to pursue. I spent the following years deliberately making career choices with the goal of getting a tenure-track job at a community college. This talk will share my personal experiences with this process, from networking, searching for open positions, and the interview process to my experiences as a first-year instructor.

ED04: 3-3:30 p.m. What a TYC Search Committee Wants You to Know

Invited – Brooke Haag, American River College, 4700 College Oak Dr., Sacramento, CA 95841-4286; HaagB@arc.losrios.edu

Having taught physics at two-year colleges both as an adjunct and full-time instructor, I have been on both sides of a search committee. While an interview can be a daunting prospect, with the right preparation, like anything else it can be mastered. One key to optimal preparation is knowing what a search committee is looking for in the process of a new faculty hire. I will share insights gleaned, through the benefit of hindsight and the perspective of many interviews, as to what a search committee looks for during the interview process.

Session EE: Effective Practices in Physics Teacher Preparation

Location: SSU - Prince George's
Sponsor: Committee on Teacher Preparation
Date: Tuesday, July 28
Time: 1:30–3:40 p.m.

Presider: Monica Plisch

EE01: 1:30-2 p.m. Editorial Introduction to Effective Practices on Physics Teacher Education Book

Invited – Eric Brewe, Florida International University, 11200 SW 8th St., Miami, FL 33199; ebrewe@fiu.edu

Cody Sandifer, Towson University

PhysTEC has supported a book, Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices, to be published during 2015. In this presentation, the co-editors provide an overview of the process of bringing the book to fruition. The manuscripts are organized into six sections: Preparing Future Physics Teachers: Overview and Past History; Case Studies of Successful Physics Teacher Education Programs; Recruiting and Retaining Preservice Physics Teachers; Structuring Effective Early Teaching Experiences; Preparation in the Knowledge and Practices of Physics and Physics Teaching; and Mentoring, Collaboration, and Community Building. We provide overviews of the sections and highlight emergent themes from the book.

EE02: 2-2:30 p.m. Recruiting and Preparing Teachers Through Inclusive, Collaborative Physics Education Community*

Invited – Eleanor W. Close, Department of Physics, Texas State University, 601 University Dr., San Marcos, TX 78666-4615; eclose@txstate.edu

Lane Seeley, Amy D. Robertson, Lezlie S. DeWater, Seattle Pacific University

Hunter G. Close, Texas State University

Over the past decade, the Department of Physics at Seattle Pacific University (SPU) has transformed itself in ways that have enabled it to successfully recruit and prepare a large number of physics teachers for an institution of its size. In this presentation we will identify the main components that

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contribute to SPU's success, organized according to three themes: programmatic and structural supports, intellectual resources, and faculty and student dispositional commitments. We will also discuss the ongoing process of translating these components for implementation in a significantly different institutional context, a process undertaken by two former SPU physics faculty now at Texas State University. An overarching theme in both institutions has been the creation of an inclusive community around the practice of physics education, within an academic setting that includes formal learning environments that value and promote the development of interactive academic skills such as argumentation and group collaboration.

*Supported in part by NSF DUE 1240036

EE03: 2:30-2:40 p.m. A Fast-Track Teacher Preparation Program at UNC-CH

Contributed – Alice D. Churukian, University of North Carolina at Chapel Hill, Department of Physics & Astronomy, CB 3255 Phillips Hall, Chapel Hill, NC 27517; adchuruk@physics.unc.edu

Laurie E. McNeil, University of North Carolina at Chapel Hill

At the University of North Carolina at Chapel Hill, the College of Arts & Sciences and the School of Education partnered together to develop a fast-track teacher preparation program called UNC-BEST (University of North Carolina Baccalaureate Education in Science and Teaching). Students in the UNC-BEST program are science or mathematics majors who, in addition to the courses for their majors, complete the requirements for subject specific, secondary licensure in North Carolina. The program graduated its first teachers in 2009 and continues to grow. How the program came into existence, the collaboration among the departments within the College of Arts and Sciences and the School of Education, and where we are today will be discussed.

EE04: 2:40-2:50 p.m. Periscope: Looking into Learning in Best Practices University Physics Classrooms

Contributed – Rachel E. Scherr, Seattle Pacific University, 3307 3rd Ave. W, Seattle, WA 98119; rescherr@gmail.com

Renee Michelle Goertzen, American Physical Society

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.

EE05: 2:50-3 p.m. Physics Teacher Preparation at the University of Arkansas

Contributed – John Stewart, West Virginia University, 135 Willey St., Morgantown, WV 26506; gbstewart@mail.wvu.edu

Gay Stewart, West Virginia University

The University of Arkansas–Fayetteville implemented changes in its undergraduate physics program beginning in 1994 that dramatically increased the number of students graduating with a major in physics from an average of 1-2 students per year for most of the years from 1990-1998 to 27 graduates in 2012. With the selection of the department as a PhysTEC program in 2001, the number of physics students entering high school teaching also began to dramatically increase. The features that led to the increase in physics graduates were important to increasing the number of teachers graduated, but each feature required refinement to support future teachers. The refinements most important to increasing the number of highly qualified physics teachers graduated will be discussed. The complexity of helping students into the teaching profession is illustrated by case histories of successful teaching candidates.

EE06: 3-3:10 p.m. Recruiting and Retaining Future Physics Teachers at the University of Wisconsin–La Crosse*

Contributed – Jennifer L. Docktor, University of Wisconsin–La Crosse, Department of Physics, 1725 State St., La Crosse, WI 54601; jdocktor@uwlax.edu

Gubbi Sudhakaran, University of Wisconsin–La Crosse

The University of Wisconsin–La Crosse has reformed its secondary teacher education preparation program in an effort to increase the number of students pursuing careers in teaching and to improve the overall experience students have in the program. We will highlight changes we feel have been particularly effective, including establishing a "point person" in the Physics Department to mentor teacher candidates and collaborate with the School of Education, reforming coursework taken by future teachers, and providing students with opportunities for early teaching experiences as learning assistants and through outreach events.

*This material is based on work supported by the Physics Teacher Education Coalition (PhysTEC) and the National Science Foundation under Grant No. 0808790, 0108787, and 0833210.

EE07: 3:10-3:20 p.m. Strengthening a Physics Teacher Education Program Using the SPIN-UP Report

Contributed – Bruce Palmquist, 400 E. University Way, Mail Stop 7422, Ellensburg, WA 98926-7422; palmquis@cwu.edu

Michae Jackson, Central Washington University

For the past decade, the Central Washington University Physics Department has implemented recommendations from the Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP) report* to strengthen its physics teacher education program. 1) The physics and mathematics departments partnered to develop a dual-degree program in physics and mathematics education, improving time to degree and certifying students in two high-needs fields. 2) Introductory courses were converted to 40-50 student lecture/lab classes using best practices pedagogies, modeling effective physics teaching for preservice teachers. 3) All majors, including pre-service teachers, do a mentored research project, giving pre-service teachers authentic research experiences so they can model science practices to their students. 4) A Learning Assistant program was developed to improve student learning in introductory courses, provide early teaching experiences, and furnish training in basic action research. These changes have led to more than doubling the number of physics majors and physics teacher candidates.

*http://www.aps.org/programs/education/undergrad/faculty/spinup/spinup-report.cfm

EE08: 3:20-3:30 p.m. Composing Science: A Scientific Inquiry Course for Future Teachers*

Contributed – Leslie Atkins, California State University, Chico, 400 W 1st St., Chico, CA 95929-0535; ljatkins@csuchico.edu

This presentation describes a course in open scientific inquiry for preservice teachers. The course uses neither a textbook nor a lab manual, but instead engages students in developing models of puzzling phenomena through an iterative process of designing experiments, crafting models, debating, and refining ideas. I discuss basic structures in the class, including introducing an initial question or phenomenon, engaging in small-group investigations, leading whole-class conversations, and assessing students' work. Included are a range of examples of student ideas and student work, and results of surveys on students' progress.

*Support from NSF 1140860 and 1140785.

EE09: 3:20-3:40 p.m. The Early History of Physics Teacher Education in the United States

Contributed – Keith Sheppard, SUNY at Stony Brook University, 56 Midwood Ave., Nesconet, NY 11767; keith.sheppard@stonybrook.edu

Amanda Gunning, Mercy College

The present high school physics course and the preparation of teachers to teach the course developed from the work of notable physicists and educators such as Edwin Hall, Charles Riborg Mann, Robert Millikan, and John Woodhull. During a period of extraordinary growth of high schools in the United States, they had experiences in education that positioned them to be champions of physics education reform. This chapter examines the development of physics teacher education from the post-revolutionary period until the Second World War, highlighting the importance that laboratory work played in shaping the course and in preparing physics teachers.

Session EF: High School

Location: Jimenez Hall (JMZ) - 0105
Sponsor: AAPT
Date: Tuesday, July 28
Time: 1:30–2:20 p.m.

Presider: James Lincoln

EF01: 1:30-1:40 p.m. Integrating a Holistic View of Energy Principles into High School Physics

Contributed – Ann Reimers, Department of Energy, 217 Cornwall St. NW, Leesburg, VA 20176; areimers703@gmail.com

The study of energy and the energy industry involves concepts from physics, chemistry, biology and environmental science. But a comprehensive view of energy also involves integrating the civics, history, economics, sociology, psychology, and politics of the use of energy into the discussion. Most high schools will not offer a course dedicated to the understanding of energy, but energy literacy is an important attribute of an informed citizenry. Many of the interdisciplinary aspects of understanding energy can be efficiently integrated into a high school physics class. This talk will discuss how several concepts in the Department of Energy's Energy Literacy Framework can be added to familiar high school physics labs and projects to enrich the learning experience and increase alignment with NGSS.

EF02: 1:40-1:50 p.m. Inferring Content Knowledge for Teaching Energy (CKT-E): What Different Sources of Data Tell Us About One Teacher's CKT-E*

Contributed – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave. W, Suite 307. Seattle, WA 98119-1997; robertsona2@spu.edu

Rachel E. Scherr, Abigail R. Daane, Seattle Pacific University

"Content knowledge for teaching" (CKT) is the specialized content knowledge that teachers use in practice—the content knowledge that serves them for tasks of teaching such as making sense of students' ideas, selecting instructional tasks, and assessing student work. This knowledge is complex and multi-faceted, such that different sources of data showcase different facets of a teacher's CKT. We coordinate data from one teacher's pre- and post-instructional interviews, video observations of classroom instruction, instructional materials, and analysis of her own students' work to infer the content knowledge for teaching energy (CKT-E) that is on display in these different contexts. We argue that no single source of data fully captures a teacher's CKT-E but that certain sources are especially well suited for inferring particular aspects of teachers' CKT-E. Researchers may use our results to coordinate their data collection efforts with the specific CKT that they wish to study.

*This material is based upon work supported by the National Science Foundation under Grant No. 122732.

EF03: 1:50-2 p.m. New Harmonies: Activities and Insights for Learning Physics and Music

Contributed – Daniel N. Bergman, University of Manitoba, 1-828 Preston Ave., Winnipeg, MB R3G 0Z4, Canada; daniel.n.bergman@gmail.com

Richard P. Hechter, University of Manitoba

Music is something that resonates with people, regardless of culture, ethnicity, and skin colour. From listening to the radio, or playing a band, to fancying different genres from classical to blues, pop, or hip hop - there seems to be something for everybody. Embracing music is something that physics teachers can demonstrate for students as an authentic context for learning the science of sound found within high school physics curricula. This presentation describes an activity we developed as an introduction to a sound unit in a high school physics class. The lesson aims to engage a wide range of students through the universal power of music through a hands-on and minds-on experience towards multi-disciplined studies in music and physics. Further, we will describe how an activity like this can reduce tensions of a musically inexperienced physics teacher in terms of incorporating musical elements into a lesson. Thank you to the University of Manitoba and the Faculty of Education for conferring me the Undergraduate Research Award and enabling me to work on this project, as well as Dr. Richard Hechter for working with me on the research.

*Thank you to the University of Manitoba and the Faculty of Education for conferring me the Undergraduate Research Award and enabling me to work on this project, as well as Dr. Richard Hechter for working with me on the research.

EF04: 2-2:10 p.m. International 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

It is often difficult to identify characteristics of classroom lessons of a particular country because teaching is buried in tradition. International comparative studies in education can reveal those characteristics by bringing very different pictures together. Based on the earlier work of a comparative study of U.S. and Chinese high-school physics lessons,[1] this study examines how Indonesian lessons are similar to and different from U.S. and Chinese lessons. As a pilot study, four lessons in two private high schools in an urban city in Indonesia were collected. RTOP (Reformed Teaching Observation Protocol) was used for the analysis. The preliminary results indicate that Indonesian lessons have characteristics that are similar to those of U.S. as well as those of China. Cultural implications of the results are discussed.

1. S. Tosa and L. Qian, (2014). Comparison of U.S. and Chinese High-School Physics Teaching and the Need for Active Learning at the College Level, Proceedings of the 12th Asia Pacific Physics Conference, JPS Conf. Proc., 017002-1-6.

EF05: 2:10-2:20 p.m. Physics Teacher Support Group: A Virtual PLC

Contributed – Kelly C. O'Shea, Little Red School House & Elisabeth Irwin High School (LREI), 40 Charlton St., New York, NY 10014; kellyoshea@gmail.com

For the past three years, a small group of five to eight physics teachers from different schools in different parts of the country has met for a weekly video chat. We share student work, discuss what students might be thinking and how to help them, and check in with each other about our successes and challenges. It is a place to bring our problems so that we can discuss them with like-minded colleagues and work to improve our practice. We have found it to be a rich source of professional development and support. In this talk, I will share details about how the group meets and the content of our typical discussions, and I will try to provide advice for those hoping to start their own virtual Professional Learning Community (PLC).

Session EG: Improving Departmental Climate for Women and Under-represented Ethnic Groups

Location: Jimenez Hall (JMZ) - 0220
Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Geraldine Cochran

EG01: 1:30-2 p.m. Graduate Student Developed Initiatives Toward Equity in the Physical Sciences

Invited – Angela Little, Michigan State University, 1464 W Farragut Ave. #2, Chicago, IL 60640; little@berkeley.edu

Initiatives aimed at supporting equity in physics are often developed by university administrators and faculty. However, graduate and undergraduate students have also played a central role in the development of new programs. In this talk, I will focus on equity-related programs founded by graduate students in the physical sciences. I will first discuss the landscape of such programs, highlighting long-standing as well as newer efforts. As the co-founder of one such initiative, The Compass Project at UC Berkeley, an APS award-winning program, I'll highlight Compass in more depth. I will go into detail on how Compass was founded and what sources of support helped it to get off of the ground. I will also discuss how involvement in such programs can provide graduate students with important professional skills and a support network crucial to completing their PhD's.

EG02: 2-2:30 p.m. From Deficit Model of Women and Minorities to White Male Privilege: A Reframing for New Growth

Invited – Melissa Dancy, University of Colorado, Physics Department, Boulder, CO 80309-0001; melissa.dancy@gmail.com

For many years the issue of low representation of women and people of color in physics has been a recurring topic of discussion and the focus of numerous initiatives. Despite the intense and ongoing efforts to change the situation, the percent of women obtaining bachelors degrees in physics increased mostly linearly from 6% in 1967 to 20% in 2012. This implies that, at our current rate of progress, women will make up 50% of graduates around the year 2095. The situation for under-represented minorities is even more dismal with their obtainment of bachelor's degrees only now at the 1967 levels for women. In this talk I argue that the historical theoretical framing of the issue has been a deficit model of women and people of color and that a more fruitful model is that of white male privilege. Using data from my own research as well as others, I will frame this argument and illuminate new avenues suggested by the privilege framing.

EG03: 2:30-3 p.m. Professional Learning Communities: Building Voice in the Department

Invited – Leanne Wells, Florida International University, AHC 4, Room 358, 11200 SW 8th St., Miami, FL 33199; lwells@fiu.edu

In the face of a decade of declining numbers of physics bachelor's degrees awarded to women and underrepresented minorities, we outline Florida International University's (FIU) successes in transforming courses critical to STEM degrees and focus on how professional learning communities contribute not only to the success of these transformations but also to creating a voice within departments for those traditionally not heard. We examine the cases of members of three sets of professional learning communities at FIU – a Physics Education Research Group with group members including students, research faculty, teaching faculty, and staff; a Discipline-Based Education Research Group with members being a diverse group of mostly research faculty; and a Precalculus Algebra Course Transformation group with all members being female and/or from an underrepresented population. We present participant perceptions of voice and influence within these communities and within their departments and discuss implications for student identity and persistence.

EG04: 3-3:30 p.m. Improving Departmental Climate for Women and Under-represented Ethnic Groups

Invited – Edmund Bertschinger, MIT, 77 Massachusetts Ave., Cambridge, MA 02139; edbert@mit.edu

Creative, collaborative effort to advance a respectful and caring community can leverage the power of diversity, improve student and faculty success, and enhance the quality of life for everyone. I will describe the successful efforts made to increase diversity and excellence at MIT and continuing efforts we are making to create a culture of empowerment and respect for everyone.

Session EH: Lab Guidelines Focus Area 1: Constructing Knowledge

Location: Art-Sociology Building (ASY) - 2203
Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 28
Time: 1:30–3:20 p.m.

Presider: Joe Kozminski

EH01: 1:30-2 p.m. A Conversation with Nature: Constructing Knowledge in the TYC Course

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

From the Guidelines:* "The laboratory curriculum should get students to start thinking like physicists by constructing knowledge that does not rely on an outside authority, should explicitly make them aware that they can construct knowledge in this way, and should build confidence in their ability to do so." The first year of college seems a suitable time to acquire this ability if a student does not already possess it and physics is a particularly useful place to teach this. Physics is foundational for STEM fields and introductory physics applies to much of everyday life. Inquiry methods and small class sizes allow one to achieve some measure of success with this in a TYC. This talk will describe some elements of a curriculum with this focus, how one may communicate these goals and aspirations with students, integrating lab and lecture, and some specific examples as illustrations of the methods employed.

**Recommendations for the Undergraduate Physics Laboratory Curriculum*

EH02: 2-2:30 p.m. Using Laboratories to Help Students Construct and Test Concepts

Invited – Eugenia Etkina, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901-1183; eugenia.etkina@gse.rutgers.edu

Traditionally in instructional labs students verified accepted knowledge and applied knowledge to solve simple problems where their answer could be compared to an "accepted value." In both types students had to learn "theory" first. Changes in science education, and specifically in physics education, call for the new type of labs: the labs where students develop and test their own ideas and participate in authentic physics practices. How do we structure those labs and do they lead to student learning? In this talk I will share the findings of more than 10 years of studies of such labs and will provide recommendations on how to structure them to make students successful.

EH03: 2:30-2:40 p.m. Studying Student Engagement in Science Practices Using their Lab Reports

Contributed – Danielle Buggé, West Windsor-Plainsboro High School, South 346 Clarksville Rd., West Windsor, NJ 08550; danielle.bugge@gse.rutgers.edu

Eugenia Etkina, Rutgers University

Science practices are an integral part of learning science. However, mastering such practices is a complicated process for all learners, especially high school students. Unfamiliarity with an inquiry-based environment and open-ended problems that do not have one correct solution can be perceived as frustrating for these learners. How do students cope with these challenges and how long does it take them to become comfortable? We implemented ISLE labs that focus on the development of student scientific abilities in a high school physics course during one academic year and collected data containing the descriptions of designed experiments and student reflections. The data allowed us to answer questions related to the development of science practices for young learners including time required for development of specific abilities as well as the level of proficiency. We also investigated differences in individual and group reports and students' self-assessments and reflections.

EH04: 2:40-2:50 p.m. Letters Home as an Alternative to Lab Reports

Contributed – W. Brian Lane, Jacksonville University, 2800 University Blvd., North, Jacksonville, FL 32211; wlane@ju.edu

The traditional lab report is known to create several pedagogical shortcomings in the introductory physics course, particularly in regards to promoting student engagement, helping students develop their own understanding, and encouraging quality writing. We have found that replacing the traditional lab report with a Letter Home[1] written to a non-physicist creates a more authentic post-lab writing experience, promoting a deeper "unlearning" process for students during and after the lab activity. We discuss the structure of this assignment and how it can be bridged to the traditional technical paper genre.

1. W. Brian Lane, *The Physics Teacher* **52**, 397 (2014).

EH05: 2:50-3 p.m. Why Not Try a Scientific Approach to Science Laboratory Architecture?

Contributed – James C. Martin, University of Alabama at Birmingham, 1014 Shades Crest Rd., Birmingham, AL 35226-1906; jcmartin@uab.edu

Lauren Rast, Robert D. Collins, David L. Shealy, University of Alabama at Birmingham

Significant critiques of lab procedures have provided inspiration for innovation. The 2014 AAPT lab document advocated students constructing knowledge. Carl Wieman addressed cognitive activity discrepancies between students and professional researchers. We will discuss a novel lab architecture responsive to these insights in which: students access a simplified online "literature" of lab content, experimental results, and research tools, not a traditional lab manual. Over a term students: digest existing "articles" (which start as "stubs"); discover weaknesses; design and implement better investigations; write "manuscripts," not lab reports; and submit them for "publication." Instructor "referees" triage submissions using a rubric emphasizing: constructing and extending knowledge; and communicating professionally. Stronger articles are published in an online "journal" adding to or replacing existing articles; others are returned with specific suggestions for improvement. This approach is: applicable across content fields and course formats; facilitated by modern software tools; and a source of useful course analytics.

EH06: 3-3:10 p.m. Quantifying Measurement Error and Interpreting Confidence Intervals

Contributed – W. Blake Laing, Southern Adventist University, PO Box 370, Collegedale, TN 37315; LAING@SOUTHERN.EDU

Sean Bryant, Southern Adventist University

A first lab experiment clearly illustrates that a home glucose meter is actually an excellent source of both random and systematic error, much to the surprise to students and physicians alike. A histogram is constructed and the utility of the standard deviation and standard error to quantify the uncertainty in each measurement and in the mean value, respectively, is demonstrated. From the first lab on, students are challenged to express and interpret confidence intervals in order to form quantitative conclusions. Assessments reveal that many science majors find this to be surprisingly challenging.

EH07: 3:10-3:20 p.m. Knowledge Construction in Electronics: Online Concept Modules and Hands-on Challenges

Contributed – Robert C. Davis, Brigham Young University, N215 ESC Provo, UT 84602-0002; davis@byu.edu

Cheryl B. Davis, Brigham Young University

Rethinking our introductory electronics course (the first course in our laboratory sequence) in the context of both existing course objectives and in light of the new AAPT laboratory curriculum guidelines is resulting in a shift in our laboratory approach. Debugging is a key experimental skill objective but has often been hindered by poor mastery of basic circuit conceptual understanding resulting in non-ideal dependence on TAs. We are also seeing untapped opportunities for constructing knowledge that could deepen the course content and increase engagement. However, the development of debugging skills and activities that are structured to foster the construction of knowledge are very challenging in this one credit hour class without mastery of some basic concepts. We will present on the use of adaptive online pre-lab exercises to aid basic concept mastery followed by structured hands-on challenges.

Session EI: PER: Examining Content Understanding and Reasoning II

Location: John S. Toll Physics Building (PHY) - 1412
Sponsor: AAPT
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Gina Passante

EI01: 1:30-1:40 p.m. "Because Math": Epistemological Stance or Defusing Social Tension in QM?*

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

Benjamin Dreyfus, Ayush Gupta, Andrew Elby, University of Maryland

Often in environments where students are collaboratively working on physics problems, students need to manage social conflict alongside grappling with conceptual and epistemological differences. At the University of Maryland, our PER group has been developing QM tutorials to help students more carefully navigate between classical and quantum models. In this presentation, we document several outlets that students use as tools for social framing and managing social conflict. These resources include epistemic distancing, humor, playing on tutorial wording and looking ahead to subsequent questions. Our data come from video-records of a focus group at the University of Maryland, where students work through a tutorial on the Particle in a Box. We see evidence of students using mathematics in ways that may normally be interpreted as indicating an epistemological stance, but are actually used as a means of defusing social tension.

*Work supported by NSF-DUE 1323129

EI02: 1:40-1:50 p.m. "Classical-ish": Negotiating the Boundary Between Classical and Quantum Particles*

Contributed – Benjamin William Dreyfus, University of Maryland, College Park, Department of Physics, 082 Regents Dr., College Park, MD 20742; dreyfus@umd.edu

Erin Sohr, Andrew Elby, Ayush Gupta, University of Maryland

Developing physical intuition about quantum mechanics can seem like a departure from our everyday experience of the physical world, but we build new ideas from our existing ones. In this presentation we examine video data from a focus group doing a tutorial about the "particle in a box." In reasoning about the properties of a quantum particle, the students bring in elements of a classical particle ontology, which are evident not only through the students' language but through their use of gestures. But this is modulated by metacognitive moments in which the group explicitly takes up questions of whether classical intuitions are valid for the quantum system. Through this reflection, the students find some cases in which classical ideas can be usefully applied to quantum physics, and others in which they directly contrast classical and quantum mechanics. Negotiating this boundary is part of the process of building quantum intuitions.

*This work is supported by NSF-DUE 1323129.

EI03: 1:50-2 p.m. Particle or Wave: Supporting Students' Ontological Development in Modern Physics*

*Contributed – Jessica Hoy,** University of Colorado Boulder, 680 S. Lashley Ln #110, Boulder, CO 80305; jessica.hoy@colorado.edu*

Noah Finkelstein, Kathleen Hinko, Doyle Woody, University of Colorado

Learning quantum mechanics requires students to develop not only new mathematical skills but also conceptual understanding. Towards this instructional goal, the Modern Physics for Engineers course at the University of Colorado Boulder explicitly addresses interpretation of quantum phenomena. Research indicates that when instruction does not explicitly address student beliefs about the nature of a subject, the students' ideas tend to become less expert-like (Atman, et al., 2007). We present new data from focus groups of students enrolled in this course. During recorded discussions, they negotiate the tension between reasoning about light in terms of classical (wave-like) and quantum (particle-like) ontologies. We examine transitions in students' ontological reasoning about light as well as their use of energy as a bridge between classical and quantum ideas. Finally, we consider fostering students' metacognitive awareness as a route to expert-like behaviors in quantum mechanics.

*Work supported by NSF

**Sponsored by Noah Finkelstein

EI04: 2-2:10 p.m. Investigating Physics and Engineering Students' Understanding of Diode Circuits*

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

Kevin L. Van De Bogart, Christos P. Papanikolaou, University of Athens

David P. Smith, University of North Carolina at Chapel Hill

As part of a larger project at the University of Maine to investigate the learning and teaching of concepts in thermodynamics and electronics that are integral to both undergraduate physics and engineering programs, we have been examining student learning in electrical engineering and physics courses on electric circuits and electronics. A major goal of this work at the physics-engineering interface is to probe the extent to which the nature of student understanding (including the prevalence of specific difficulties) depends upon the disciplinary context. In this talk, I will focus on our efforts to probe student understanding of basic diode circuits using free-response questions. Preliminary results from questions administered in both physics and engineering courses will be presented.

*This work has been supported in part by the National Science Foundation under Grant Nos. DUE-1323426, DUE-1022449, and DUE-0962805.

EI05: 2:10-2:20 p.m. The Pedagogical Value of Conceptual Metaphor for Secondary Science Teachers*

Contributed – Abigail R. Daane, Seattle Pacific University, 3307 3rd Ave., West, Seattle, WA 98119; daanea@spu.edu

Jesper Haglund, Uppsala University

Amy D. Robertson, Rachel E. Scherr, Seattle Pacific University

Hunter Close, Texas State

The abstract nature of energy encourages the use of metaphorical language in educational settings. K-12 teachers and students use conceptual metaphors implicitly to express their ideas about what energy is or how it functions in particular scenarios. Attending to the use of conceptual metaphors in the classroom can expand teachers' repertoire for formative assessment of student ideas. Yet science education research on analogies and metaphors has predominately focused on explicit, instructional analogies, rather than attending to such implicit, ubiquitous features of natural language in science. In a secondary science teacher professional development course, we observe teachers engage in an instructional activity designed to increase awareness of conceptual metaphor in everyday language and in descriptions of energy. These teachers come to value the application of conceptual metaphor in educational settings; they acknowledge that if they identify metaphors present in their students' science language, they will better understand their students' ideas about energy. We present possible mechanisms for teacher growth in learning and valuing the use of energy metaphors and illustrate how to support teachers in noticing, understanding, and valuing metaphors for energy.

*This material is based upon work supported by the National Science Foundation under Grants No. 0822342 and 1222732.

EI06: 2:20-2:30 p.m. Energy in Physics and Chemistry: Helping Students Draw Interdisciplinary Connections

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

Megan L. Nagel, Penn State Greater Allegheny

Energy is a topic that spans the scientific disciplines. Many studies conducted within the domains of both physics and chemistry demonstrate that potential energy in particular is a difficult topic for students. Previous work has shown that even within physics, students do not necessarily draw on ideas from mechanics when answering questions about potential energy in the context of electrostatics. We have been engaged in a research project aimed at helping students to make productive use of their ideas about gravitational potential energy when asked questions in the context of electrostatics. In this talk, we will report on recent findings regarding what helps students to draw these connections. We will present data from small-group interviews and online surveys, and we will discuss the implications these data have for instruction on energy in introductory courses.

EI07: 2:30-2:40 p.m. Changes in Student Reasoning About Graphical Work During Introductory Physics*

Contributed – John R. Thompson, University of Maine, Department of Physics & Astronomy, Orono, ME 04469-5709; thompsonj@maine.edu

Jessica W. Clark, University of Maine

In a study on student understanding of graphical representations of work, students in introductory calculus-based physics were presented with a force-position graph (F-x) that showed two different mechanical processes with identical initial and identical final values for force and position. The task, to compare the works done in each case, was administered at three points along the two-semester instructional sequence to probe differences in student responses and reasoning and compare findings to results from analogous questions in thermodynamics. Response prevalence varied little across administrations; however, the reasoning students used showed variation. Analysis of reasoning used showed a higher use of "area under the curve" for a correct response, and a more prevalent invocation of "path independence" or "conservative forces" for the major incorrect interpretation, with instruction. These findings support earlier speculation that thermodynamics students associate work with conservative forces due to introductory instruction.

*Supported in part by NSF Grant DUE-1323426.

EI08: 2:40-2:50 p.m. Student Understanding and Construction of Differentials in Introductory Physics

Contributed – Nathaniel Amos, Ohio State University, 4751 Blairfield Dr., Columbus, OH 43214; amos.93@osu.edu

Andrew Heckler, Ohio State University

Introductory university physics frequently involves the construction of integrals. There is evidence to suggest that a major obstacle to student success in the construction of physics integrals is an inability to formulate and interpret differentials and products involving differentials. We provided introductory calculus-based physics students with several physics problems featuring infinitesimal quantities in a variety of contexts in order to identify potential misconceptions regarding physical differentials. Our results demonstrated several broad, recurring student difficulties. To address these issues, we conducted a controlled experiment at the introductory level to help students practice the construction and explore the physical meaning of differentials. This between-students design featured pairs of similarlystyled training tasks that varied by physical context, either on paper without feedback or on a computer with electronic feedback. A post-test was given to all conditions. We will discuss and analyze the results of these studies.

EI09: 2:50-3 p.m. Student Inferences from Two-Dimensional Graphs with Multiple Independent Variables

Contributed – Abigail M. Bogdan, The Ohio State University, 191 West Woodruff Ave., Columbus, OH 43210-1168; bogdan.22@osu.edu

Andrew F. Heckler, The Ohio State University

In this study, students' ability to draw inferences from graphs was explored. Approximately 300 students, in either the first or second semester of an introductory, calculus-based physics course, were given simple two-dimensional graphs and asked to draw inferences about the relationship between the dependent variable and each of three independent variables shown in the graph. The common strategies students employed and the pitfalls they encountered in doing this were observed. Additionally, the effect of students' prior belief on their ability to draw valid inferences was assessed by presenting graphs either in a familiar physical context or in a more generic context. We found students were generally able to read simple graphs; however, their ability was affected by the consistency of their prior beliefs with the data, their numeric ability, and the complexity of the graph. These results are consistent with previous studies done with data tables.

EI10: 3-3:10 p.m. Student Generation of General Rules Supports Learning of Physics Principles

Contributed – Eric Kuo, Stanford University, 450 Serra Mall, Bldg. 160, Stanford, CA 94305; erickuo@stanford.edu

Carl E. Wieman, Stanford University

Through a classroom study, we investigated whether student attempts to invent general physics principles support both discovery and future learning of those principles. In introductory physics discussion sections, small groups of students used a PhET simulation to connect ideas from topographic contour maps to electric equipotential lines for two sample charge configurations. The goal was for students to find the relationship between the electric field and the equipotential lines. On a conceptual survey administered immediately after this activity, students directed to create general rules performed better than students led through case-by-case predictions. This differential was maintained some days later, after both groups had received instruction in lecture and lab on the topic. This indicates that the task of explicit generalization not only supports discovery of general physics principles, but also prepares students for improved future learning from instruction.

EI11: 3:10-3:20 p.m. Learning Introductory E&M: A 50+ Institution Meta-analysis

Contributed – Ulas Ustun, Kansas State University, Cardwell 401, Manhattan, KS 66506; ulasustun@gmail.com*

Eleanor Sayre, Kansas State University

The DEAR-Faculty project is a large, international, multi-methods study to investigate student learning in introductory physics. As part of this project, we conduct meta-analyses of published data using popular research-based conceptual assessments such as the Force Concept Inventory (FCI). In this talk, I present a meta-analysis of student learning in electricity and magnetism. We concatenated data from a comprehensive literature search of papers published in PhysRevST-PER, AJP, and the PERC proceedings, and/or indexed in ERIC, Scopus, or Web of Science. We selected all primary studies that present sufficient data on the two most popular EM assessments: the Conceptual Survey of Electricity and Magnetism (CSEM), and the Brief Electricity and Magnetism Assessment (BEMA). Our data set includes 50 studies representing about 60 schools. We calculated the effects of institution and teaching methods on student learning, as well as some overall statistics on the heterogeneity of the data set.

*Sponsored by Eleanor Sayre

EI12: 3:20-3:30 p.m. University Student Conceptual Resources for Understanding Energy

Contributed – Hannah C. Sabo, Seattle Pacific University, 3307 3rd Ave. W, Seattle, WA 98119; saboh@spu.edu

Lisa M. Goodhew, Amy D. Robertson, Seattle Pacific University

On the basis of our analysis of responses to written questions administered to large numbers of introductory physics students at several universities across the United States, we report the specific, recurring conceptual resources that students use to reason about energy. This work responds to a need for large-scale, resources-grounded research on students' conceptual understanding and supports the development of an underexplored dimension of pedagogical content knowledge—knowledge of student resources for understanding energy, in contrast to misconceptions or misunderstandings about energy. We aim to promote instructor take-up of the resources theory of knowledge, and we suggest a number of ways in which instructors might capitalize on the resources we report.

*This material is based upon work supported by the National Science Foundation under grant #122732

Session EJ: Research on ExtraSolar Planets

Location: John S. Toll Physics Building (PHY) - 1410
Sponsor: Committee on Space Science and Astronomy
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Kevin Lee

EJ01: 1:30-2 p.m. The Promise and Challenge of Research on Extrasolar Planets from Space

Invited – Mark Clampin. GSFC GSFC, 8800 Greenbelt Rd., Greenbelt, MD 21204; mark.clampin@nasa.gov*

During the last decade the number of confirmed planets outside our solar system has become a deluge, and we have started to probe the atmospheric composition of exoplanet atmospheres. I examine the early techniques of extrasolar planet detection, and show how observations from space with missions such as Kepler and COROT have greatly expanded the catalog of exoplanet candidates. Space missions have also played a major role in the characterization of exoplanet atmospheres. I will discuss have planned survey missions such as the Transiting Exoplanet Survey Satellite (TESS) will add to our understanding of exoplanets, and discuss the future role of the James Webb Space Telescope. Finally, I will review the search for life problem and discuss candidate observations that would attempt to find evidence of life, together with the missions required to undertake such observations.

*Sponsored by Kevin Lee

EJ02: 2-2:30 p.m. Exoplanet Genetics: What Host Star Chemical Abundances Reveal About Planetary System Formation and Composition

Invited – Johanna Teske, Carnegie Institution of Washington, 5251 Broadbranch Rd., Washington, DC 20015; jteske@carnegiescience.edu

Though the ultimate goal of astronomers is to discover Earth 2.0, most exoplanets that we know of appear to be very different than Earth, and even distinct from the other planets in our Solar System. From the very first detections, astronomers have striven to understand what factors influence exoplanet formation, evolution, and composition – what is responsible for the vast diversity in observed planetary systems? Through the process of star and planet formation we think that "genes," or chemical abundances, of host stars are in some way passed on to their orbiting planets. In this talk, I will present results of ongoing high precision spectroscopic studies of host star abundances to investigate how/to what extent planet composition, atmospheric and interior, is dependent on host star composition.

EJ03: 2:30-3 p.m. Characterizing the Atmospheres of Extrasolar Planets: Seeking a Habitable World

Invited – Drake Deming, University of Maryland, 1116 Physical Sciences Complex, College Park, MD 20742; lddeming@gmail.com

Ashlee Wilkins, University of Maryland

Measuring the properties of exoplanetary atmospheres informs us concerning the formation and evolution of planetary systems, and can in principle identify conditions favorable for life. We have been able to characterize the atmospheres of exoplanets over a wide range of sizes, from planets larger than Jupiter to planets only modestly larger than Earth. However, the exoplanets characterized to date are all relatively hot worlds, well above habitable temperatures. Future advances in high contrast imaging, and continued discovery of planets transiting bright stars, will allow us to probe nearby worlds orbiting in the habitable zones of their stars. I will describe two tracks to characterizing the atmospheres of habitable exoplanets. One track will use the James Webb Space Telescope to observe habitable planets transiting red dwarf stars, and the other track will use a coronagraphic technique to image a world like our own Earth orbiting a star like our Sun.

EJ04: 3-3:30 p.m. Future Exoplanet Missions: Towards Habitable Worlds

Invited – Aki Roberge, NASA Goddard Space Flight Center, Exoplanets and Stellar Astrophysics Lab, Greenbelt, MD 20771; Aki.Roberge@nasa.gov

To our delighted surprise, over the last decade we have found that planetary systems around other stars are far more abundant and diverse than astronomers expected. Some appear like the Solar System, with planets on orderly, nearly circular orbits. But many others have planets quite unlike the ones in our system, like hot Jupiters and super-Earths. We have now begun to examine these planets in more detail, and will do far more in the near future with the James Webb Space Telescope. All these discoveries encourage us to start planning for an even bigger goal, searching for habitable conditions on the surfaces of planets outside the Solar System and seeing if any might have signs of life. In this talk, I will discuss NASA's current plans and future visions for space telescope missions that could advance detailed studies of exoplanets, leading towards the world-shaking goal of finding biosignatures on a world around another star.

Session EK: Research on Teamwork

Location: Art-Sociology Building (ASY) - 2309
Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 28
Time: 1:30–3:30 p.m.

Presider: Rebecca Lindell

EK01: 1:30-2 p.m. Teamwork: Insights from 40 Years of Research and Practice

Invited – Karl A. Smith, University of Minnesota, 1954 Buford Ave., Minneapolis, MN 55455-0213; ksmith@umn.edu

Systematic research on teamwork (or groupwork as it is referred to by many researchers) has been conducted for well over 40 years.[1, 2] I started experimenting with cooperative learning in my engineering classes in the early 70s. Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning.[3,4,5,6] High performance teamwork is at the heart of effective use of cooperative learning.[7] I'll summarize key findings of the research that informed the implementation of cooperative learning as well as the development of Teamwork and project management, now in its 4th edition.[8] As physics instruction shifts to an increasing use of challenge-based learning (e.g., problem based, SCALE-UP, inquiry based, etc.) understanding and implementing effective teamwork is essential.[9,10,11]

1. Maier, N.R.F. 1970. Problem solving and creativity in individuals and groups. Brooks/Cole. 2 Steiner, I.D. 1972. Group process and productivity. New York: Academic Press. 3. Johnson, D.W., Johnson, R.T., 1974. Instructional goal structures: Cooperative, competitive, or individualistic. Review of Educational Research, 44, 213-240. 4. Smith, K.A., Johnson, D.W. and Johnson, R.T. 1981. Structuring learning goals to meet the goals of engineering education, Engineering Education, 72 (3), 221-226. 5. Johnson, D.W., Johnson, R.T., and Smith, K.A. 1991a. Cooperative learning: Increasing college faculty instructional productivity, ASHE-ERIC Reports on Higher Education. 6. Johnson, D.W., Johnson, R.T., and Smith, K.A. 1991b. Active learning: Cooperation in the college classroom, 1st Ed. Edina, MN: Interaction Book Company. 7. Johnson, D.W., Johnson, R.T. & Smith, K.A. 2007. The State of Cooperative Learning in Postsecondary and Professional Settings. Educational Psychology Review, 19, 15–29. 8. Smith, K.A. 2014. Teamwork and project management, 4th Ed. New York: McGraw-Hill. 9. The Board on Behavioral, Cognitive, and Sensory Sciences of the National Academies. Consensus study on the science of team science http://sites.nationalacademies.org/DBASSE/BBCSS/CurrentProjects/DBASSE_080231
10. Freeman, S., Eddy, S. L., McDonough, M., Smith, M.K.; Okoroafor, N., Jordt, H., Wenderoth, M. P. 2014. Active learning increases student performance in science, engineering, and mathematics. Proceedings National Academy of Science, 111(23), 8410–8415. 11. Chi, M.T.H. 2009. Active-Constructive-Interactive: A Conceptual Framework for Differentiating Learning Activities. Topics in Cognitive Science 1, 73–105.

EK02: 2-2:30 p.m. The Role of Social Positioning and its Effect on How Groups Function

Invited – David T. Brookes, Florida International University, 11200 SW 8th St., Miami, FL 33133-2009; dtbrookes@gmail.com

Yuehai Yang, California State University, Chico

Binod Nainabasti, Florida International University

In a student-centered inquiry classroom such as the ISLE physics class at FIU, the social dynamics of the learning community are key to its success or failure. Groups of three students work together on learning activities, creating whiteboards which they then present to the rest of the class, building scientific consensus together as part of a learning community. Given two groups composed of students of comparable intellectual ability, what makes one group so much more effective than another and are there intragroup behaviors that set these two groups apart? Our research is motivated by our desire to understand the social dynamics of groups and quantify these dynamics in an objectively measurable way. We will present some of our data that shows a) what an "effective" group looks like and b) the underlying patterns of social maneuvering that makes an "effective" group function so well.

EK03: 2:30-3 p.m. From Classroom Impact to Research Tool: CATME Team Tools

Invited – Matthew W. Ohland, Purdue University, 701 W Stadium Ave., West Lafayette, IN 47907; ohland@purdue.edu

The CATME Team Tools, consisting primarily of criterion-based team formation using Team-Maker and CATME Peer Evaluation, have been used by more than 350,000 students of over 7000 faculty of more than 1200 institutions in 63 countries. This popularity is backed by validation of the CATME Peer Evaluation in multiple contexts. Others have begun to use CATME Peer Evaluation results in their own research, which speaks to a different kind of impact. The large dataset of ratings data that have been de-identified and released voluntarily comprise another research resource. This latter dataset certainly provides ongoing information about the instrument's psychometric properties. While that dataset is very large, little else can be learned except where there are other outcome variables that can be related to rating behaviors because of the absence of a "true score" for comparison. Where additional outcomes are available, fascinating research questions can be asked.

EK04: 3-3:10 p.m. Group Formation and Student Response Patterns on Group Exams

Contributed – Steven F. Wolf, Texas State University, 601 University Dr., San Marcos, TX 78666-4615; sfw18@txstate.edu

Christopher W. Gardner, Yinebeb Y. Zenaw , Hunter G. Close, Texas State University

There have been recent national calls echoing the need to improve instruction in the scientific practices. Working together to solve a problem is one of the most fundamental skills a physicist will need to master to be effective after graduation. At Texas State University, group exams are used to give our assessments the same active and collaborative feel that our classes have. Using a duplicate exam format, we are developing a method for analyzing group formation for a particular exam using the framework of network analysis. We are furthermore studying response patterns on these group exams to see the benefit to students. We present an exploratory study of group exam behavior. In the future, student participation in the network will be leveraged to study relationships between exam participation and broader student behaviors such as course grade and overall persistence in the discipline and retention at the university.

EK05: 3:10-3:20 p.m. Using Reflection to Assess Perceptions of Teamwork in Undergraduate Seminar

Contributed – Kevin A. Nguyen, Texas Tech University, 201 Indiana Ave., Lubbock, TX 79415; kevin.a.nguyen@ttu.edu*

Weile Yan, Beth Thacker, Texas Tech University

Students entering college have perceptions about what effective teamwork and communication should look like, and it is then important to initially gauge their ideas about teamwork and communication in order to correct any misconceptions or incorrect notions. Reflection can be a tool to assess students' perceptions and beliefs about effective teamwork and communication. Undergraduate STEM students at a four-year university are asked to perform a challenging team-based marshmallow activity. Students are then prompted to reflect on their experience and are explicitly asked how well their team did and to provide feedback on improvement. Some common themes from the reflection include: not enough involvement, leadership issues, and need to improve listening skills. Students are able to correctly discuss what effective teamwork and communication should look like, and the themes provide specific areas to work on moving forward. The marshmallow activity appears to prompt reflection and discussion on teamwork.
*Sponsored by Beth Thacker

EK06: 3:20-3:30 p.m. Perceptions of Learning and Teamwork: Practice-based Introductory Physics

Contributed – James Brian Hancock, II, Michigan State University, 250C Erickson Hall, East Lansing, MI 48824; hancoc14@msu.edu

Paul Irving, Marcos (Danny) Caballero, David Stroupe, Vashti Sawtelle, Michigan State University

At Michigan State University, one section of a calculus-based introductory physics course for scientists and engineers has been transformed to focus on developing students' use of scientific practices (e.g., developing and using models, designing experiments, using computational modeling) through participation in a community-based learning environment. We present qualitative data from interviews with students based on their participation in the calculus-based course, which we call Projects and Practices in Physics (P3). In this course, students learn core physics concepts by engaging with scientific practices. The researchers investigated student perceptions of learning through the practices developed in P3. Preliminary results on the perception and nature of teamwork and learning in this environment (and how those perceptions are connected) will be presented, as well as potential implications to consider when incorporating scientific practices and alternative teaching methods in undergraduate introductory physics courses.

Session EL: Astronomy

Location: SSU - Atrium
Sponsor: AAPT
Date: Tuesday, July 28
Time: 1:30–2:20 p.m.

Presider: Todd Timberlake

EL01: 1:30-1:40 p.m. Continuing Upgrades for the University of West Georgia Observatory

Contributed – Bob Powell, University of West Georgia, Department of Physics, Carrollton, GA 30118; bpowell@westga.edu

Benjamin Jenkins, University of West Georgia

The University of West Georgia Observatory has been serving the West Georgia students and the surrounding community since it was built in 1979. It is used for a mandatory laboratory assignment, a required honors course assignment, optional extra credit regular lecture sections, and student research projects. It is also a resource for the public and broader university community to observe astronomical events. During the last year we have updated and modified several aspects of the observatory to provide better outreach experiences and more comprehensive observations. These changes include expanded solar studies, newly acquired spectroscopes, the installation of a large monitor to show attendees extended length exposures of deep sky objects, and the installation and use of a 14" inch Celestron 1400 in the main dome for student use in our astrophysics course and for future student research projects.

EL02: 1:40-1:50 p.m. Student Perception of iPads and eBooks in Introductory Astronomy

Contributed – Kristen L. Thompson, Davidson College, Box 7133, Davidson, NC 28035; krthompson@davidson.edu

Mario Belloni, Davidson College

With the rise of technology in classrooms, the last few years have seen an increase in the use of both iPads and electronic textbooks (eBooks) as instructional tools. However, their effectiveness in the classroom is a topic of widespread debate. We have been engaged in developing an interactive eBook for use in a one-semester introductory astronomy course. This book, Astronomy: An Interactive Introduction, was used as the sole text in the fall 2014 astronomy course taught at Davidson College. Students enrolled in this course were provided an iPad containing the eBook and various astronomy-related applications for use throughout the semester. In this talk, I will discuss the use of the iPad and eBook in the astronomy course, as well as present the results of an end-of-semester survey designed to probe student response to the use of this technology in the classroom.

EL03: 1:50-2 p.m. Extremophiles and Astrobiology: A Science-focused IB Group 4 Project

Contributed – Janet Kahn, George C. Marshall High School 7731 Leesburg Pike, Falls Church, VA 22046; jlkahn@fcps.edu

Mark Fredenburg, Jean Hayhurst, Michael Osborn, Nimel Theodore, George C. Marshall High School

Marshall High School has 150 students each year taking an exam in IB Science or Design Technology classes, who are required to participate in the Group 4 Project. Working in interdisciplinary teams, the students should address the IB Aims of developing communication skills, raising awareness of implications of using science and technology, and understanding the relationships between the sciences. We ran a successful and popular project where student groups were assigned a class of extremophile. Each group was tasked with choosing one organism, finding another place in our solar system that has a similar environment, and designing an appropriate probe to collect the needed data to verify whether the lifeform is present. Students found the research question compelling, and enthusiastically designed experiments, instrumentation, and a vehicle capable of reaching the planet or moon, then running the experiment and transmitting the data to Earth.

EL04: 2-2:10 p.m. Virtual Astronomy Labs for Online Courses

Contributed – Gregory L. Dolise, Harisburg Area Community College, 1 HACC Dr., B232F, Harrisburg, PA 17110; gldolise@hacc.edu

Students taking an introductory astronomy course often start with little prior knowledge and many misconceptions. Frequently they are taking the course only to meet a science requirement and may not be prepared for the rigors of a college science class. This is particularly true for students taking online courses. Labs are a constant source of difficulty in online instruction because students find paper and pencil exercises boring, may lack proper math skills, and require a significant amount of help. Planetarium software can be used to replace traditional labs with exercises both visual and interactive. This talk will discuss using such software, giving examples based on 14 years of development. Approaches to how to engage students, how to combat misconceptions, and how to develop understanding of difficult concepts.

EL05: 2:10-2:20 p.m. The Rotation of the Milky Way Galaxy

Contributed – Todd K. Timberlake, Berry College, PO Box 5004, Mount Berry, GA 30149-5004; ttimberlake@berry.edu

Adam Jarrell, Berry College

Models for the rotation of the Milky Way Galaxy went through several changes between Lindblad and Oort's first proposals for differential galactic rotation in the 1920s and modern models that incorporate a dark matter halo. We will briefly survey this history and then present a computer simulation that allows the user to explore various models for the Milky Way's rotation. The simulation illustrates how model parameters affect the galactic rotation (or circular velocity) curve, and also how the rotation curve affects directly observable quantities such as the radial velocities of stars. This connection to observable quantities allows the user to determine the set of parameter values that best fits the data.

EL06: 2:20-2:30 p.m. Progress and Development of a Template Space Science Curriculum

Contributed – Abebe Kebede, North Carolina A&T State University, 1601 East Market St., Greensboro, NC 27411-0001; gutaye@ncat.edu

Currently there is a fully functional space science concentration within the BS in Physics program at NC A&T State University. It is a template curriculum that allows students to take 18 cr. space science course and with electives course in Electrical Engineering or Mechanical Engineering or Earth Sciences. The new curriculum in undergraduate space science concentration includes courses like Introduction to Astronomy (PHYS101), Introduction to Space Science (PHYS280), Introduction to Astrophysics (PHYS451) Introduction to Solar Physics (PHYS480), Introduction to Space Radiation (PHYS490), Introduction to High Energy Astrophysics (PHYS580) and Special Topics in Physics (PHYS500 and PHYS700). Space Weather (ECE4984) course is available via video conferencing from Virginia Tech, using facilities of the National Institute of Aerospace. In this communication we will provide a full description of the curriculum.

AAPT PHYSICS EDUCATION

Awards Session:
AIP Andrew Gemant Award: *Ainissa Ramirez*

Location: SSU - Hoff Theater
Date: Tuesday, July 28
Time: 4–5 p.m.

Presider: Janelle M. Bailey

Ainissa Ramirez

Our Sputnik Moment in STEM Education

It wasn't that long ago when Sputnik—a beach-ball size satellite—was launched into the Russian sky and galvanized America to reexamine its commitment to science education. Today, we need to make a similar recommitment to science, technology, engineering and math (STEM) as evidenced by our international testing scores. Yet the numbers on a page do not garner the same reaction as that satellite did long ago. Additionally, those who do STEM do not reflect the demographic of our nation, which means that not all perspectives are part of this larger national conversation. Moreover, as new materials are made, such as nanotechnology, all citizens need to be aware of the impact of such innovations—both positive and negative. This current situation underscores the value of science teachers. This talk will make a case for the importance of STEM education, will discuss some of the fascinating work in nanotechnology, and will emphasize why science teachers are key to not only improving science literacy, but to sustaining democracy.

PST2: Poster Session

Location: SSU - Colony Ballroom
Date: Tuesday, July 28
Time: 5–6:30 p.m.

Odd number poster authors should be present 5-5:45 p.m.
Even number poster authors should be present 5:45-6:30 p.m.
(Posters should be set up by 8 a.m. Tuesday and then taken down by 6:30 p.m. Tuesday)

A - Astronomy

PST2A01: 5-5:45 p.m. A Textbook for Using Astronomy to Teach Physics

Poster – Enrique J. Galvez, Colgate University, 13 Oak Dr., Hamilton, NY 13346; egalvez@colgate.edu

Joseph C. Amato, Colgate University

We present the chapter structure and examples of an upcoming textbook title on introductory calculus mechanics: "Physics from Planet Earth." It emphasizes conservation laws, and uses astronomical themes and examples without sacrificing conventional mechanics. A first part emphasizes conservation of momentum, starting with motion, velocity, momentum, collisions, and center of mass. Going with these are themes such as Hubble law, rocket propulsion, and planetary flybys. A second part focuses on forces, covering acceleration, Newton's laws, circular motion, oscillations, Kepler's laws, and gravitation. It has rich astronomical themes that go with it, such as orbital motion, binary stars, exoplanets, and rings vs. moons. A third part covers energy and its conservation, highlighting gravitational potential energy. It is used to introduce escape velocity and planetary transfer orbits. A fourth part treats rotations, angular momentum, and torques, showcasing pulsars and the precession of equinoxes. A final synthesis highlights dark matter and dark energy.

PST2A02: 5:45-6:30 p.m. Change for the Better: Improving Astronomy Students' Attitudes about Science

Poster – Shannon D. Willoughby, Montana State University, MSU Bozeman 224 EPS, Bozeman, MT 59717; willoughby@physics.montana.edu

Keith Johnson, Montana State University

Student attitudes toward science were measured for two years in Astronomy 110 using the Epistemological Beliefs about the Physical Sciences Survey. This data revealed that we should target two areas of student attitudes: whether or not the ability to learn science is a fixed human trait and how science knowledge is accumulated - absorption of facts versus integration with prior knowledge. The course was modified so that students were regularly reflecting on these two target areas; we also more closely linked the lecture material with discussions of the nature of science, skepticism, and metacognitive tasks. The EBAPS was administered in the modified course for two semesters and further information was collected through audio taping interviews with students concerning their views of science. Statistical comparisons of EBAPS data between the baseline and modified courses are presented here, as are the materials developed to address our two target areas.

PST2A03: 5-5:45 p.m. Implementing and Assessing Interactivity in Astronomy Demonstration Videos

Poster – Kevin M. Lee, University of Nebraska, National Science Foundation, 244D Jorgensen Hall, Lincoln, NE 68588-0111; klee6@unl.edu

Cliff Bettis, Lisa PytlikZillig, Cristina Riley, University of Nebraska

AU is a series of short videos of physical demonstrations appropriate for use in introductory astronomy classes. Considerable effort is made to make the videos interactive through embedded peer instruction questions and accompanying worksheets. This poster will illustrate the interactive mechanisms in recently developed videos on retrograde motion and stellar hydrostatic equilibrium. It will also present early results on a study of student engagement in different modes of video presentation. These materials are publicly available at http://astro.unl.edu and on YouTube and are funded by NSF grant #1245679.

PST2A04: 5:45-6:30 p.m. Leveling the Playing Field of Physics Through International Collaboration and Outreach in Space Studies in Ethiopia

Poster - Abebe Kebede, North Carolina A&T State University, 1601 East Market St., Greensboro, NC 27411-0001; gutaye@ncat.edu

Wanda Diaz, Harvard University

Amde Amdesilliassie, University of Gondar

Recent advances in space exploration and astrophysical studies provide a fertile ground for international collaboration in these fields. In this communication we will describe our recent work in Ethiopia in collaboration with the Ethiopian Scientific and Academic Network (ESAN), University of Gondar, Adama University of Science and Technology, Debre Tabor University and a handful of schools and colleges in Arsi Asela Areas. Our activities led to the establishment schools that provide short-term advanced courses and hands-on training and use of radio jove, Sudden Ionospheric Disturbances (SID) monitors and use and operation of remotely controlled telescopes around the world. Space science in Ethiopia is in its beginning stages. The penetration of such vital resources is very limited in Ethiopia because of lack of information and limited knowledge of astronomy and space science. Our activities also include teacher training to help teachers access these resources and use them effectively in classrooms. Our collaboration paid specially attention to the underrepresentation of women in physics, and adaptive technologies for the blind. In this communication we present our recent activities in Ethiopia and the progress of our collaboration

PST2A05: 5-5:45 p.m. Lightcurve Analysis of Six Asteroids

Poster – Melissa N. Hayes-Gehrke, University of Maryland, Department of Astronomy, College Park, MD 20742; mhayesge@umd.edu

We present the lightcurves of six asteroids and preliminary rotation period determinations. The asteroids were chosen by an undergraduate non-major class at the University of Maryland and observed in 2015 March/April using telescopes in Spain and New Mexico owned by itelescope.net and operated remotely by the students. We would like to thank the Astronomy Department of the University of Maryland for their support in this class.

PST2A06: 5:45-6:30 p.m. The Astronomy Workshop Extragalactic: Web Tools for Use by Students

Poster – Melissa N. Hayes-Gehrke, University of Maryland, Department of Astronomy, College Park, MD 20742; mhayesge@umd.edu

Alberto D. Bolatto, University of Maryland

The Astronomy Workshop Extragalactic (http://carma.astro.umd.edu/AWE) is a collection of interactive web tools that were developed for use in undergraduate and high school classes and by the general public. The focus of the tools is on concepts encountered in extragalactic astronomy, which are typically quite difficult for students to understand. Current tools explore Olbers' Paradox; the appearance of galaxies in different wavelengths of light; the Doppler Effect; cosmological redshift; gravitational lensing; Hubble's Law; cosmological parameters; and measuring masses of black holes by observing stellar orbits. The tools have been developed by undergraduate students under our supervision and we are continuing to add more tools. This project was inspired by the Astronomy Workshop (http://janus.astro.umd.edu) by Doug Hamilton which has web tools exploring more general astronomical concepts. We would like to thank the NSF for support through the CAREER grant NSF-AST0955836 and grant NSF-AST1412419, and the Research Corporation for Science Advancement for a Cottrell Scholar award.

PST2A07: 5-5:45 p.m. Creating Opportunities for Astronomy Majors to Collaborate in Introductory Courses

Poster – Derek C. Richardson, University of Maryland, Department of Astronomy, College Park, MD 20742-2421; dcr@astro.umd.edu*

Alice Olmstead, Fatima Abdurrahman, Allison Bostrom, Sarah Scott, Melissa N. Hayes-Gehrke, University of Maryland

The University of Maryland courses ASTR120 and ASTR121 form a two-semester introduction to astrophysics required for the Astronomy major. Here we report on successes and challenges of transforming the courses to be more student-centered, drawing on existing research-based strategies and creating a new lab curriculum that teaches skills relevant for professional astronomers. We aim to provide equitable learning opportunities for all potential astronomy majors, by creating space for them to collaborate and reason about the content during class. We are adopting and building on materials that have been developed for astronomy non-majors (including Peer Instruction questions and Lecture-Tutorials). We are also using two-stage exams, where the second stage allows students to collaborate outside of class, in order to reduce stereotype threat and better align our assessments with other changes to the course. This effort is supported in part by a grant from the University of Maryland TLTC Elevate Fellows program.

*Sponsored by Alice Olmstead

B – Pre-college/Informal and Outreach

PST2B01: 5-5:45 p.m. Promoting Critical Evaluation in the Science Classroom*

Poster – Doug Lombardi, Temple University, 1301 Cecil B. Moore Ave., Philadelphia, PA 19122; doug.lombardi@temple.edu

Janelle M. Bailey, Temple University

"A Framework for K-12 Science Education" states that critique and evaluation of scientific explanations has been under emphasized in many science classrooms (NRC, 2012). Consequently, this lack of instruction has, in part, contributed to students not being able to critically evaluate alternative explanations of natural and engineered phenomena. The Model-Evidence Link (MEL) diagram, originally developed by researchers at Rutgers University (Chinn & Buckland, 2012), is an instructional scaffold that promotes students to critically evaluate alternative explanations and increase their ability to understand complex scientific concepts (Lombardi, Sinatra, & Nussbaum, 2013). Our poster will feature four MEL diagrams that focus on the following science topics: climate change, wetland resources, fracking, and the Moon's formation. These MELs are being developed as part of NSF-funded project, with all materials being freely available to instructors.

*This work is based upon work supported by the NSF under Grant No. DRL-131605. Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not necessarily reflect the NSF's views.

PST2B02: 5:45-6:30 p.m. Can Teachers Help Undo Climate Myths?

Poster – Gordon J. Aubrecht, Ohio State University at Marion, 1465 Mt. Vernon Ave., Marion, OH 43302-5695; aubrecht.1@osu.edu

As educators and citizens, we have been disappointed to see science slighted in many policy areas, including global warming. This poster will suggest how we can help bring the reality of human-caused climate change to the attention it deserves.

PST2B03: 5-5:45 p.m. Impact of Physics Modeling Instruction Workshops on Physics Major Production

Poster – Idaykis Rodriguez, Florida International University,11200 SW 8th St., Miami, FL 33199; irodr020@fiu.edu

David Jones; Florida International University

Over the past 10 years, Florida International University (FIU) has conducted summer Modeling Instruction workshops for high school physics teachers. The workshops have impacted teachers and also influenced the number of physics majors at FIU coming from these participating high schools. We collect data of physics majors at FIU for the past 10 years and determine which of these majors come from high schools participating in the Modeling workshops. Out of the 56 schools that participated in the Modeling workshops, 29 of the schools have produced over 90 physics majors, where 40% of those majors come from five high producing schools. The physics teachers at these schools have long-standing ties with the FIU physics community by participating in all three Modeling workshops, monthly Fizmo meetings, and communicating with FIU faculty and staff. We also present interviews of teachers commenting of the strengths of FIU and local high school partnership.

PST2B04: 5:45-6:30 p.m. Enhancing Physics Demonstration Shows Through Use of the Arts

Poster – Timothy D. Uher, University of Maryland, College Park, MD 20742; tuher@physics.umd.edu

Donna M. Hammer, University of Maryland

Physics demonstrations are widely used by universities in undergraduate education and public outreach to engage students and teach physics concepts. At the University of Maryland, the Physics is Phun public demonstration programs are a vehicle for public outreach with longstanding success (dating back to 1982). A recent program, "Out of the Dark," presented the evolution of the fields of electricity and magnetism by merging physics demonstrations with history and performing arts. In this session, we will discuss methods by which these outside fields can be utilized in a demonstration program. We will also discuss the outcomes of these methods in enhancing engagement of audience members and undergraduate majors alike.

C – Upper Division and Graduate

PST2C02: 5:45-6:30 p.m. Aerodynamics of Simple Structures

Poster – Joel C. Berlinghieri, The Citadel, Physics Department, Grimsley Hall, 171 Moultrie St., Charleston, SC 29409; berlinghieri@citadel.edu

Marc J. Eteve, Samuel K. Long, The Citadel, Physics Department

A wind tunnel can be used to investigate the aerodynamic characteristics of various shaped objects. Undergraduate physics majors, for their senior research requirement, investigated the lift, drag, and turbulence produced by blunt shaped objects. Blunt shape structures are of particular interest in designing radar evading aircraft, are usually aerodynamically unstable, and are often difficult to fly, requiring computer assistance. Measurements were made at speeds where incompressible flow can be assumed. Models were fashioned from simple but robust materials such as paper and plastic card stock using printed patents and from ABS plastic using 3D printing scripts.

PST2C03: 5-5:45 p.m. Core Graduate Courses: A Missed Learning Opportunity?*

Poster – Alexandru Maries, University of Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 12560; alm195@pitt.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.

PST2C04: 5:45-6:30 p.m. Developing a New Laboratory Course to Prepare Students for Graduate Research in Astrophysics

Poster – Christine Lindstrom, Oslo and Akershus University College, Pilestredet 52 Oslo, Oslo NO-0130 Norway; christine.lindstrom@hioa.no

Saalih Allie, University of Cape Town

Heather Lewandowski, University of Colorado, Boulder

Preparing undergraduate students for research is often one of the main goals of upper-division physics lab courses. We are developing a new upper-division lab course at the University of Cape Town in South Africa for students aiming to pursue graduate study in astrophysics. The course will build on the Advanced Lab transformation work done at the University of Colorado. We will study how to transfer the educational reform (e.g., philosophy, structure, materials, etc.) to a new environment. The first stage of the project focuses on identifying what knowledge and skills PhD advisers would like students to have when they begin their graduate research project, and to evaluate what knowledge and skills a representative student cohort has prior to taking such a laboratory course. We will report on the study methodology and initial results of faculty and student interviews.

PST2C05: 5-5:45 p.m. Developing a Quantum Interactive Learning Tutorial (QuILT) on the Double-slit Experiment

Poster – Ryan T. Sayer, University of Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15260; RTS36@pitt.edu

Alexandru Maries, Chandralekha Singh, University of Pittsburgh

Learning quantum mechanics is challenging even for upper-level undergraduate students and graduate students. Interactive tutorials that build on students' prior knowledge can be effective tools to enhance student learning. We have been investigating student difficulties with the quantum mechanics behind the double-slit experiment and have developed a Quantum Interactive Learning Tutorial (QuILT) that makes use of a simulation to improve their understanding. We describe the common student difficulties with the double slit experiment and the extent to which the QuILT was effective in addressing these difficulties. We thank the National Science Foundation for support.

PST2C06: 5:45-6:30 p.m. Developing a Survey of Thermodynamic Processes and First and Second Laws*

Poster – Benjamin R. Brown, University of Pittsburgh, 100 Allen Hall, Pittsburgh, PA 15260; brb10@pitt.edu

Chandralekha L. Singh, University of Pittsburgh

We developed a research-based multiple-choice survey on thermodynamic processes and first and second laws of thermodynamics. The survey was administered to students in introductory algebra-based and calculus-based courses and also to physics majors in an upper-level thermodynamics course and graduate students. Students at all levels were found to have great difficulty with these concepts. The development process of the survey and findings will be discussed.

*This work is supported by the NSF.

PST2C07: 5-5:45 p.m. The Optical-Mechanical Analogy in Galilean and Special Relativity

Poster – Roberto Salgado, University of Wisconsin-La Crosse, Department of Physics, 1725 State St., La Crosse, WI 54601; rsalgado@uwlax.edu

We explore an analogy between the Lagrangians of a light ray expressed in terms of angle, of a classical free particle in terms of velocity, and of a relativistic free particle expressed in terms of rapidity. Similar to our earlier observation that the classical and relativistic kinetic energies can be expressed in terms of the Spacetime Trigonometry analogues of a now little-used trigonometric function (the Versed-Sine), these Lagrangians can be expressed in terms of analogues of the Secant, or more naturally, the Exsecant. These analogies support the argument by Enzo Tonti that, in general, the Kinetic Energy is more closely related to the Hamiltonian and that it is the Legendre transform of the Kinetic Energy that is more closely related to the Lagrangian.*

*Aspects of Spacetime Trigonometry can be found at http://www.aapt.org/doorway/Posters/SalgadoPoster/SalgadoPoster.htm.

PST2C08: 5:45-6:30 p.m. Experiments for Junior Mechanics

Poster – Grey M. Tarkenton, Applied & Computational Physics, LLC, 263 Summit Dr., Bailey, CO 80421; comtneer97@gmail.com

We pay too little attention to demonstrations and experiments in upper-division physics courses. The standard junior-level mechanics topics are ripe for more sophisticated and challenging experiments that develop both experimental skills and theoretical methods. Two types of experiments are easy to set up with equipment already available: spring-coupled masses and gyroscopes. We discuss several configurations geared toward classroom demonstrations and lab activities.

PST2C09: 5-5:45 p.m. Learner Developed Podcasts in an Upper-Level Undergraduate Physics Course

Poster – Matthew Wright, Adelphi University, 1 South Ave., Blodgett Hall Room 8, Garden City, NY 11530; mwright@adelphi.edu

Bridget Grifford, Adelphi University

We assign a group project in a junior electrodynamics course requiring students to develop podcasts. We provide the topics and project plan support. However, we provide little guidance on how the students will actually approach conveying the material other than the podcast must be a 10-20 minute video and must include all group members. We report on the initial findings that students have generated insightful, fun, and engaging podcasts. In addition to learning the physics concepts, students also learn project management and communication skills.

PST2C10: 5:45-6:30 p.m. Project-based Quantum Mechanics

Poster – Gintaras Duda, Creighton University, 2500 California Plaza, Omaha, NE 68178; gkduda@creighton.edu

Although there has been interest in problem/project-based learning in the PER community as an active engagement strategy, most work done to date has focused on introductory courses. This poster will present research on upper division quantum mechanics, a junior/senior level course at Creighton University, which was taught using PBL pedagogy with no in-class lectures. Course time is primarily spent on lecture tutorials and projects, which included the alpha decay of Uranium, neutrino oscillations, spin oscillations/NMR, and FTIR spectroscopy of HCl. This poster will describe how PBL pedagogy was implemented in an upper-division physics course and will explore student learning in light of the new pedagogy and embedded meta-cognitive self-monitoring exercises, and the effect of the PBL curriculum on student attitudes, motivation, and epistemologies.

PST2C11: 5-5:45 p.m. Measurement of Model of Hadley Cell

Poster – Joel C. Berlinghieri, The Citadel, Physics Department, Grimsley Hall, 171 Moultrie St., Charleston, SC 29409; berlinghieri@citadel.edu

Shane A. Haydon, The Citadel

The mechanism for the transport of thermal energy through the atmosphere is characterized by three wind cells, Hadley, Mid-latitude, and Polar. The Hadley cell which occurs in the equatorial region assumes three properties: the atmospheric circulation is constant, angular momentum is conserved, and ground level return air is subjected to friction. A simplified model of a Hadley cell has been studied using Schlieren techniques to picture the cell and high-resolution force transducers to measure air lift.

PST2C12: 5:45-6:30 p.m. Student Difficulties with Boundary Conditions in Electrodynamics

Poster – Qing X. Ryan, University of Colorado, Boulder, 390 UCB Boulder, CO 80302; xuqing12357@gmail.com

Steven J. Pollock, Bethany Wilcox, University of Colorado Boulder

"Boundary conditions" are an important physics topic that physics undergraduates are expected to understand and apply in many different contexts. In this poster, we will present student difficulties using boundary conditions in electrodynamics, primarily in the context of electromagnetic waves. Our data sources include traditional exam questions and think-aloud student interviews. The analysis was guided by an analytical framework (ACER) that characterizes how students activate, construct, execute, and reflect on boundary conditions. Solving these problems also requires using complex notation. While this mathematical tool could be independently analyzed with ACER, we decided to blend and merge the analyses of complex notation with boundary conditions. Thus we are pushing the boundaries of situations where ACER can be applied and we will discuss the benefits and limitations of this framework.

PST2C13: 5-5:45 p.m. Developing and Evaluating a Quantum Interactive Learning Tutorial (QuILT) on Larmor Precession of Spin*

Poster – Benjamin R. Brown, University of Pittsburgh, 100 Allen Hall, Pittsburgh, PA 15260; brb10@pitt.edu

Chandralekha L. Singh, University of Pittsburgh

We have been conducting research and developing and assessing a quantum interactive learning tutorial (QuILT) on Larmor precession of spin to help students learn about time-dependence of expectation values in quantum mechanics. The QuILT builds on students' prior knowledge and helps them organize their knowledge hierarchically. It adapts visualization tools to help students build physical intuition about these topics. Details of the development and assessment will be discussed.

*This work is supported by the NSF.

PST2C14: 5:45-6:30 p.m. The Role of Metacognition in Troubleshooting in Upper-division Electronics Courses*

Poster – Kevin Van De Bogart, 120 Bennett Hall, Orono, ME 04469; kevin.vandebogart@maine.edu

MacKenzie R. Stetzer, University of Maine

As part of an ongoing effort to assess and promote student metacognition in physics, we have been examining student metacognitive abilities in the context of upper-division laboratory courses on analog electronics. While there are many important goals of laboratory instruction, particularly in upper-division courses, relatively little work to date has focused on investigation of how students in such courses troubleshoot malfunctioning circuits. In collaboration with researchers at the University of Colorado, we have been conducting think-aloud interviews with pairs of students as they attempt to troubleshoot a basic operational-amplifier circuit. Video data were analyzed in order to examine the relationship between the troubleshooting strategies employed by students and the metacognitive behaviors they exhibited (e.g., planning, monitoring, and evaluating). Preliminary results will be presented and implications for instruction will be presented.

*This work has been supported in part by the National Science Foundation under Grant Nos. DUE-1245313, DUE-1323426, and DUE-0962805.

D – Lecture/Classroom

PST2D01: 5-5:45 p.m. Three Case Studies on Student Attention in a Physical Science Class

Poster – David Rosengrant, Kennesaw State University, 1000 Chastain Rd., Marietta, GA 30062; drosengr@kennesaw.edu

Samuel Parker, Kennesaw State University

Jessica Lang, Cambridge High School

Previous research on student attention has been limited to observation, notebook analysis, or assessments that measure retention. In this set of three separate case studies we used an eye-tracker to study student attention. This tool allows us to follow what students look at during class. This presentation is the result of three separate semesters where we conducted a case study on one student in each semester. The same physical science class was the setting for each of the three semesters. The students taking the course (and those in the study) were all elementary education majors. The first semester had a student who was diagnosed with ADD. The second semester had an adult student taking the class and the final semester involved a traditional (21 year old) student. We analyzed differences in gaze patterns among the three students and how differences in content areas (physics versus chemistry versus astronomy) affected their attention.

PST2D02: 5:45-6:30 p.m. Desert Island Survival Physics 101

Poster – Mikhail M. Agrest, The Citadel, 87 Droos Way, Charleston, SC 29414; magrest@citadel.edu

"Give me a fulcrum and I will move the world" - shouted Archimedes, finding a perfect solution. Which is the best? A solution implemented with a perfect tool, or the Desert Island Survival Solution – one, executed with bare hands? A student stuck at a Desert Island on her way back from the Spring Break. Being inspired by her teacher's solving problems via reasoning from the conceptual principles all the way to the answer; she did come up with a result without the unavailable Internet, but had an error that led to an incorrect answer. Another student based his answer on the information acquired from the Internet. Just a few steps led to the absolutely correct solution. Which work you would assign a higher grade? The author will share some examples of providing unnecessary information as well as examples of how to find solutions from limited, but sufficient conceptual information.[1,2]

1. M. Agrest. Lectures on Introductory Physics I and II. 249 pp. and 252 pp. with illustrations Thomson Learning. ISBN 1426625596, 2007, ISBN 0-759-39304-4, 2006.
2. M. Agrest. Lectures on General Physics I and II. 257 pp. and 237 pp. with illustrations. Thomson Learning. ISBN 0-759-35047-7, ISBN 0-759-36060-X, 2005

PST2D04: 5:45-6:30 p.m. Modeling the Physical World: An Integrated Freshman Physics/Calculus Class

Poster – Gintaras Duda, Creighton University, 2500 California Plaza, Omaha, NE 68178; gkduda@creighton.edu

Randall Crist, Nathan Pennington, Creighton University

A physicist and two mathematicians (the authors) have been teaching a combined calculus and introductory physics course at Creighton University since fall 2011. Calculus II is paired with Physics I and Calculus III (multi-variable) is paired with Physics II. This team-taught class uses a combination of lecture with active-engagement elements and project-based learning. This experiment also provides a model for inter-disciplinary teaching that is increasingly difficult given the sizes of most physics/mathematics courses and the difficult budgetary climates at many institutions. This poster will discuss student learning in this environment, the benefits of this tight integration between math and physics (to both students and faculty), and potential improvements in the future. We will particularly discuss the lessons learned after four years of teaching modeling, and comment on how to bring new instructors into the course as old instructors rotate out.

PST2D05: 5-5:45 p.m. Testing the Waters at Princeton

Poster – Jason Puchalla, Princeton University, Department of Physics, Jadwin Hall, Princeton, NJ 08544-1098; puchalla@princeton.edu

A new introductory Physics for the Life Sciences course (PHY108) is being developed at Princeton University to meet the changing needs of biology and life science majors on campus. A desired outcome of this development effort is the option for biology majors to enroll in a one-semester physics course that is not limited to topics traditionally found in the first semester of a two-semester sequence. In Spring 2015, we offered a limited-enrollment version of this course intended to field-test various new (for Princeton) teaching techniques and student interest. Some of these techniques included: a modular classroom approach that moved away from the large weekly lecture, "5-minute" hands-on demos during lecture, and written assignments drawn from non-traditional sources that included non-statndard tasks such as "create your own MCAT question". Here I present some of the motivations for these approaches, the promising outcomes of the first offering and the challenges that lie ahead.

PST2D06: 5:45-6:30 p.m. Two-Stage Exams as an Extension of Peer Learning

Poster – Kristi D. Concannon, King's College, 133 North River St., Wilkes Barre, PA 18711; kristiconcannon@kings.edu

The process of peer instruction is crucial in helping students to identify and confront their misconceptions and to critically apply the fundamental principles learned in lecture to different and more complex situations. In most cases, though, peer learning ends at exam time. I have recently begun implementing two-stage exams in my courses under 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. In this poster, I will describe the two-stage exam process and comment on my observations of its effect on student attitudes and student learning.

PST2D07: 5-5:45 p.m. Using Biomedical Curriculum in Introductory Physics for the Life Sciences

Poster – Warren M. Christensen, North Dakota State University, PO Box 5474, Fargo, ND 58105; Warren.Christensen@ndsu.edu

Levi Remily, Matt Urich, North Dakota State University

Ralf Widenhorn, Portland State University

A one-quarter-long algebra-based introductory physics course for pre-health and life science majors at Portland State features authentic biomedically inspired physics content. The course uses multimedia learning modules via the smartphysics online system. These modules include videos with biomedical experts explaining various aspects of specific biomedical equipment. Pre-lecture questions on both the medical content covered in the video media and the physics concepts in written materials provided for students were designed to probe their understanding of physics and prepare them for activities during the class. This flipped classroom allows for in-class activities such as group discussion and peer-led instruction. Following in-class instruction, students engaged with homework assignments that explore the connections of physics and the medical field in a quantitative manner. Although this course is in the pilot stage, initial results indicate that students recognize the course as being both time demanding and engaging.

PST2D08: 5-5:45 p.m. A Five-Year Assessment Plan for Physics at SCCC

Poster – Glenda Denicolo, Suffolk County Community College, 533 College Rd., Selden, NY 11784; denicog@sunysuffolk.edu

Since the spring semester of 2013, faculty of Suffolk County Community College has been engaged on a five-year plan of assessment for all its programs. We have been trained during professional development workshops on how to map our course learning outcomes (CLOs) with the program learning outcomes (PLOs). We have designed assessment tools that will probe the PLOs (through the mapped CLOs) during the five years. I will describe the mapping of CLO vs. PLO for the Physics program at SCCC, our long-term assessment plans, and the assessment tools used thus far.

E – Physics Education Research II

PST2E01: 5-5:45 p.m. "Because Math": Epistemological Stance or Defusing Social Tension in QM?*

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

Benjamin Dreyfus, Ayush Gupta, Andrew Elby, University of Maryland

Often in environments where students are collaboratively working on physics problems, students need to manage social conflict alongside grappling with conceptual and epistemological differences. At the University of Maryland, our PER group has been developing QM tutorials to help students more carefully navigate between classical and quantum models. In this presentation, we document several outlets that students use as tools for social framing and managing social conflict. These resources include epistemic distancing, humor, playing on tutorial wording, and looking ahead to subsequent questions. Our data come from video-records of a focus group at the University of Maryland, where students work through a tutorial on the Particle in a Box. We see evidence of students using mathematics in ways that may normally be interpreted as indicating an epistemological stance, but are actually used as a means of defusing social tension.

*Work supported by NSF-DUE 1323129

PST2E02: 5:45-6:30 p.m. "Classical-ish": Negotiating the Boundary Between Classical and Quantum Particles*

Poster – Benjamin William Dreyfus, University of Maryland, College Park, Department of Physics, College Park, MD 20742; dreyfus@umd.edu

Erin Sohr, Andrew Elby, Ayush Gupta, University of Maryland, College Park

Developing physical intuition about quantum mechanics can seem like a departure from our everyday experience of the physical world, but we build new ideas from our existing ones. In this presentation we examine video data from a focus group doing a tutorial about the "particle in a box." In reasoning about the properties of a quantum particle, the students bring in elements of a classical particle ontology, which are evident not only through the students' language but through their use of gestures. But this is modulated by metacognitive moments in which the group explicitly takes up questions of whether classical intuitions are valid for the quantum system. Through this reflection, the students find some cases in which classical ideas can be usefully applied to quantum physics, and others in which they directly contrast classical and quantum mechanics. Negotiating this boundary is part of the process of building quantum intuitions.

*This work is supported by NSF-DUE 1323129.

PST2E03: 5-5:45 p.m. "Tiered," Conceptual iClicker Recitation Introductions

Poster – David B. Blasing, Purdue University, 610 Purdue Mall, West Lafayette, IN 47907-2040; dblasing@purdue.edu

Rebecca Lindell, Andrew Hirsch, Purdue University

At Purdue University we are testing a method of interactive engagement in an introductory electricity and magnetism course (that has about 300 students per semester, primarily from the engineering departments). This course has weekly, 50-minute recitations, where students answer sophisticated problems in small groups of three or four. Starting in the fall of 2013, at the beginning of roughly half of our recitations, we began introducing these sophisticated problems conceptually with series of 4-6 conceptual, "tiered," iClicker questions. These series are administered by a graduate teaching assistant during the first 15 minutes. In the remaining 35 minutes, the students continue to use these concepts in their small groups to solve the same problems as their peers in recitations without the iClicker introductions. Our goal is understand which style of recitation is most effective for helping our students learn as measured by BEMA gains and course performance.

PST2E04: 5:45-6:30 p.m. A Study on Science Teaching-Learning Methods Based on Smart Learning and Group Inquiry Teaching Model Related to the Instruction of 'Weight Unit'

Poster – Kim Ji Ye, Seoul National University of Education, Seocho-gu seochojungang-ro 96 Seoul, 1 137-742, South Korea; kjye29@hanmail.net

Youngseok Jhun, Seoul National University of Education

Inquiry teaching model allows students to experience lessons that enable them to pursue research and arrive at a generalization themselves, and in this regard, can be considered effective in strengthening the problem solving ability of students. Smart learning makes learner-oriented education through the data communication learning environment using smart devices. This study of science teaching-learning methods related to the instruction of 'Weight Unit' applies smart learning and group inquiry teaching model, and its purpose is to design a lesson model for science class of elementary School and to study how it shall be able to analyze the effect on elementary science studies and to draw positive response from students. There are three points to note on the results of this study. First, test applying smart learning and group inquiry teaching method were able to draw interest and improved learning attitude from the participating students. Second, test applying smart learning and group inquiry teaching method showed improved knowledge of the participating students on fundamental concepts and theories. Third, test applying smart learning and group inquiry teaching method resulted in an improved cooperation and a strengthened problem-solving ability of the participating students.

PST2E05: 5-5:45 p.m. A Taxonomy of Conceptions About Buoyancy

Poster – DJ Wagner, Grove City College,100 Campus Dr., Grove City, PA 16127; djwagner@gcc.edu

Ashley Miller, Randon Hoselton, Shannon Armstrong, Grove City College

Numerous studies, dating back at least as far as Piaget, have used buoyancy to probe students' understanding of density. A few studies have instead probed students' understanding of buoyancy in terms of pressure, buoyant force, and Archimedes' Principle. In this poster, we present an overview of our buoyancy conception taxonomy. Included conceptions were collected both from prior studies involving subjects having a variety of ages, and from our own interviews and assessments given to college students.

PST2E06: 5:45-6:30 p.m. A Taxonomy of Conceptions About Density

Poster – Ashley Elaine Miller, Grove City College 200 Campus Dr., Grove City, PA 16127; AshleyElaineMiller@outlook.com

DJ Wagner, Grove City College

Conceptions concerning density have been the subject of many studies, dating at least as far back as Piaget. These studies have probed many aspects of density understanding in various domains. In this poster, we present a taxonomy of conceptions about density. The conceptions described in this taxonomy have been identified by prior studies and/or our own interviews and assessment results.

PST2E07: 5-5:45 p.m. AACR: Automated Analysis of Constructed Response Physics and Astronomy Questions

Poster – Matthew M. Steele, 320 S Magnolia Ave., Lansing, MI 48912; steele24@msu.edu

Mihwa Park, Mark Urban-Lurain, Michigan State University

Multiple-choice questions have long been a staple of student assessments and education research instruments. Often these items are used not because they provide the best window into student understanding, but because they provide the lowest cost per data point. The Automated Analysis of Constructed Response (AACR, www.msu.edu/~aacr) Research Group is working to provide instructors with greater insight into student thinking by building a system to automate the analysis of constructed response (open-ended, short-answer) questions. In this poster we describe the process of developing machine-scorable constructed response questions that assess some of the foundational concepts in physics and astronomy. Specifically we focus on the creation and testing of items investigating student conceptions of energy and light's role as data carrier.

PST2E08: 5:45-6:30 p.m. Aligning Course Outcomes to Marketplace Skill Demands Using GAP Analysis Methodology

Poster – C. Dianne Phillips, NorthWest Arkansas Community College, One College Dr., Bentonville, AR 72712; dphillips@nwacc.edu

Alex Stratigakis, NorthWest Arkansas Community College*

Engineering faculty at NorthWest Arkansas Community College use project-based learning to create an entrepreneurial, curriculum- based, skills development learning environment. Undergraduate students taking the Introduction to Engineering course are given the opportunity to learn the different aspects of a career in the engineering field while gaining valuable professional experience in collaborative project research and design methods. During the past two years, faculty have engaged in the functional design of curriculum based on prerequisites. Alignment of courses is done by using the newly developed GAP Analysis-Skills creation assessment, which integrates the project-based learning program level requirements, those of the course learning outcomes and those of the market-driven "Skill Quality Levels." The program level outcomes are measured with the GAP Analysis Methodology in order to ensure desirable Skill Quality Levels prior to delivery in the marketplace.

*Sponsored by C. Dianne Philiips

PST2E10: 5:45-6:30 p.m. Analogous Patterns of Student Reasoning Difficulties in Introductory Physics and Upper-Level Quantum Mechanics

Poster – Emily M. Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

Very little is known about how the nature of expertise in introductory and advanced courses compares in knowledge-rich domains such as physics. We develop a framework to compare the similarities and differences between learning and patterns of student difficulties in introductory physics and quantum mechanics. Based upon our framework, we argue that the qualitative patterns of student reasoning difficulties in introductory physics bear a striking resemblance to those found for upper-level quantum mechanics. The framework can guide the design of teaching and learning tools. This work is supported by the National Science Foundation.

PST2E11: 5-5:45 p.m. Analysis of Acquisition and Difficulties of Students Related to "Sound"

Poster – Park Hana, Seoul National University of Education, Gwangmyeong Apt., Mansu 6-dong, Namdong-gu Incheon, Korea; ASI/KR/KS006/Incheon phn47@naver.com

Youngseok Jhun, Seoul National University of Education

This study planned to find any characteristics of students' concepts, after the researcher teaches a unit of "Sound of nature" which is based on a national elementary school curriculum. In this study we intended to find the characteristics of acquisition process about the concepts of sound. And for this study, we hoped to find some areas in which students feel difficulty, and if they feel difficulty, to learn what the cause is. The researcher from this study is to understand the concept acquisition process of sound of the third grade elementary students. In addition, by analyzing the degree of difficulty associated with learning about sound, to provide implications to teaching.

PST2E12: 5:45-6:30 p.m. Aspects of Factor Analysis Applied to the Force Concept Inventory

Poster – Matthew R. Semak, University of Northern Colorado, Physics, 0232G Ross Hall, Greeley, CO 80639; matthew.semak@unco.edu

Richard D. Dietz, Cynthia Galovich, University of Northern Colorado

The application of factor analysis to the Force Concept Inventory (FCI) has proven to be problematic. Some studies have suggested that factor analysis of test results serves as a helpful tool in assessing the recognition of Newtonian concepts by students. Other work has produced at best ambiguous results. We report on our analysis of over 500 pre- and 400 post-tests. The factor structure is more pronounced in the post-test with a more readily identifiable association between factors and physical concepts.

PST2E13: 5-5:45 p.m. Assessing Gender Differences in Students' Understanding of Magnetism

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

Jing Li, Alex Maries, University of Pittsburgh

We investigate gender differences in students' difficulties with concepts related to magnetism using a multiple-choice test whose reliability and validity have been substantiated earlier. We also conduct individual interviews with a subset of students to get a better understanding of the rationale behind their responses. We find that females performed significantly worse than males when the test was given both as a pre-test and post-test in traditionally taught calculus -based introductory physics courses. In the algebra-based courses, the performance of females was significantly worse in the post-test but there was no statistical difference in the pre-test performance of males and females. We discuss possible reasons for these differences. We thank the National Science Foundation for support.

PST2E14: 5:45-6:30 p.m. Assessing the Efficacy of Computer Coaches for Problem Solving*

Poster – Evan Frodermann, University of Minnesota-Twin Cities, 116 Church St. S.E., Minneapolis, MN 55455-0213; frodermann@physics.umn.edu

Ken Heller, Jie Yang, Leon Hsu, University of Minnesota-Twin Cities

Bijaya Aryal, University of Minnesota-Rochester

This poster describes a study to measure the educational impact of computer problem-solving coaches in an introductory physics class, taking into account the multiple challenges provided by the difficulty of measuring students' problem-solving skills, constructing appropriate comparison groups, and managing the many factors that may block or mask such skills in student performance. Experimental design, data analysis, and results are presented.

*This work was partially supported by NSF DUE-0715615 and DUE-1226197.

PST2E15: 5-5:45 p.m. Assessing the Maryland Learning Assistant Program

Poster – Chandra Anne Turpen, University of Maryland, College Park 6701 Adelphi Rd., University Park, MD 20782; chandra.turpen@colorado.edu

Erin R. Sohr, University of Maryland, College Park

This presentation gives an overview of findings from the first four years of running a Learning Assistant (LA) program[1] at the University of Maryland, College Park (UMCP). At UMCP, LAs have supported educational transformation efforts across 12 different science courses and engaged 22 different instructors in research-based educational practices. In assessing the impact of this program on LAs, we have replicated CU-Boulder's finding that LAs' conceptual understanding is improved through participation in the LA program (~10% average absolute gain on FMCE[2]).[3] We are investigating the longitudinal impacts of the LA experience on LAs and how LA programs may be cultivating change agents. We find that many of our former LAs continue to be involved in some teaching and work to change how learning environments are structured. LAs also report that their experiences in the program were transformative for the ways that they thought about teaching and learning science.

1. V. Otero, N. Finkelstein, R. McCray, and S. Pollock (2006). "Who is responsible for preparing science teachers?" *Sci.*, 313, pp. 445-446.
2. R. K. Thornton and D. R. Sokoloff (1998). "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. of Phys.* **66**(4), pp. 338-352.
3. V. Otero, S. Pollock and N. Finkelstein (2010). "A physics department's role in preparing physics teachers: The Colorado learning assistant model." *Am. J. of Phys.* **78**(11), pp. 1218-1224.

PST2E16: 5:45-6:30 p.m. Background and Perspectives on the CSU Learning Assistant Program*

Poster – Mel S. Sabella, Chicago State University, Department of Chemistry and Physics, 9501 S. King Dr., SCI 309, Chicago, IL 60628; msabella@csu.edu

Andrea G. Van Duzor, Dwayne Sanders, Chicago State University

Kara Weisenburger, Chicago High School for the Arts

Miriam Schmid, Gwendolyn Brooks College Preparatory Academy

The Learning Assistant (LA) Program at CSU involves undergraduate STEM majors as facilitators in the introductory chemistry and physics classes. As LAs, CSU STEM majors participate in a pedagogy course where they explore different methods of instruction with peers, Chicago area High School Faculty, and CSU Faculty. LAs then apply these methods in a classroom setting working alongside the course instructor. LAs are given the opportunity to solidify their content understanding, build communication skills, and help other students tackle challenging coursework. Students enrolled in introductory courses can improve their understanding of the topics and be motivated by working with experienced undergraduate students. In this poster we describe the CSU LA Program from the standpoint of the LAs and describe how the expertise of High School teachers is utilized to build effective instructional practices. The CSU LA Program is based on the University of Colorado LA Program.

*Supported by the American Physical Society (PhysTEC) and CSU.

PST2E17: 5-5:45 p.m. Changes in Student Reasoning About Graphical Work During Introductory Physics

Poster – John R. Thompson, University of Maine, Department of Physics & Astronomy, Orono, ME 04469-5709; thompsonj@maine.edu

Jessica W. Clark, University of Maine

In a study on student understanding of graphical representations of work, students in introductory calculus-based physics were presented with a force-position graph (F-x) that showed two different mechanical processes with identical initial and identical final values for force and position. The task, to compare the works done in each case, was administered at three points along the two-semester instructional sequence to probe differences in student responses and reasoning and compare findings to results from analogous questions in thermodynamics. Response prevalence varied little across administrations; however, the reasoning students used showed variation. Analysis of reasoning used showed a higher use of "area under the curve" for a correct response, and a more prevalent invocation of "path independence" or "conservative forces" for the major incorrect interpretation, with instruction. These findings support earlier speculation that thermodynamics students associate work with conservative forces due to introductory instruction.

Supported in part by NSF grant DUE-1323426

PST2E18: 5:45-6:30 p.m. Classroom Technology and Belonging Among Underrepresented Students

Poster – Margaret M. McAdam, University of Maryland, Department of Astronomy, 1113 Physical Sciences Complex, College Park, MD 20742-2421; mmcadam@astro.umd.edu

Tessy S. Thomas, Chris C. Ferraioli, University of Maryland

Students from underrepresented groups (e.g. historically marginalized groups, first generation college students and students from lower socioeconomic status) may experience feelings of self-doubt and question their abilities to succeed at college.[1] These experiences contribute to the persistent achievement gap in higher education and quantitative fields such as physics [e.g. 1, 2, 3]. We conduct a mixed-methods study investigating the experience of students from underrepresented groups with technology in the classroom. Through digital literacy surveys and in-depth interviews with students at a large public research university, we specifically explore students' perceptions of technology in the classroom, their ability to effectively use this technology and potential challenges such as access or familiarity. We further investigate whether the use of digital technology in the classroom enhances or hinders students' senses of belonging (feelings of affiliation and identification with the institution) in quantitative/STEM fields.

1. Yeager, D.S., Walton, G., & Cohen, G.L. (2013). Addressing achievement gaps with psychological interventions. Phi Delta Kappan, 94(5), 62-65.
2 Lee, J. (2002). Racial and ethnic achievement gap trends: Reversing the progress toward equality? Educational Researcher 31(1), 3-12.
3. Mulvey, P. J., Nicholson, S. (2012) Physics Bachelor's Degrees: Results from the 2010 survey of enrollments and degrees. AIP Focus On, www.aip.org/statistics

PST2E19: 5-5:45 p.m. Correlating Students' Use of Multiple Representations on the FMCE

Poster – Trevor I. Smith, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028-1701; smithtr@rowan.edu

Studies show that students solve problems differently if they are posed verbally or graphically.[1] Similarly, class average scores on the Force and Motion Conceptual Evaluation (FMCE) often differ for questions involving verbal statements about forces and those involving graphs of force over time.[2] We expand on this work by examining individual students' responses to two question clusters on the FMCE (Force Sled and Force Graphs[2]) and seeking correlations between student use of both correct and common incorrect models. Data are drawn from pre- and post-instruction surveys at several institutions, including a four-year research-intensive university and a two-year college.

1. D. E. Meltzer, *Am. J. Phys.* **73**, 463 (2005).
2. T. I. Smith, M. C. Wittmann, and T. Carter, *Phys. Rev. ST Phys. Educ. Res.* **10**, 020102 (2014).

PST2E20: 5:45-6:30 p.m. Developing a Protocol to Assess Instructional Artifacts in Physics

Poster – Robert C. Zisk, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901-1281; robert.zisk@gse.rutgers.edu

Eugenia Etkina, Drew Gitomer, Rutgers University

Content knowledge for teaching (CKT) is a practice-based theory of the professional knowledge that a person needs to be able to carry out tasks of teaching in the classroom (Ball, Thames and Phelps, 2008). One such task of teaching is developing instructional materials and assessments that meet the goals of instruction. This poster will describe the development process of a protocol that we developed to assess such artifacts from the CKT point of view. We provide examples of artifacts collected from teachers used in their units on mechanical energy. These artifacts will be used to illustrate how the coding scheme captures differences in both the content of the artifacts and the types of tasks the students must complete. Finally, initial results from coding of artifacts from 10 teachers will be compared to other measures of teachers' Content Knowledge for Teaching Energy.

PST2E21: 5-5:45 p.m. Discovering Mechanics Problems with Dependent Responses in a MOOC

Poster – Trevor A. Balint, George Washington University, 725 21st St., Washington, DC 20052; tabalint@gwu.edu

Raluca Teodorescu, George Washington University

Kimberly Colvin, University of Albany-SUNY

Youn-Jeng Choi, David Pritchard, Massachusetts Institute of Technology

We searched for pairs of problems that students answer similarly in the MIT's MOOC 8.MReVx. We plan to use such pairs, or groups of pairs, to identify skills that students actually use to solve problems. To avoid false dependencies that arise when skillful (unskillful) students answer both problems correctly (incorrectly), we divided the students into ability-based groups using three sorting methods: skill from Item Response Theory, success rate on attempted problems, and success rate on all problems. The results show similar trends for all three methods, with each method yielding consistent numbers of dependent problem pairs well above chance. We will discuss our findings, implications for instruction, as well as our plans to cluster the pairs of problems and identify the types of skills associated with each cluster.

PST2E22: 5:45-6:30 p.m. English Skills for Physics

Poster – Stephen March, 605 Good Springs Rd., Brentwood, TN 37027; steve@marchco.net

English skills are vital for students in learning physics. This poster shows the result of research into which English skills are the most important for success in a physics class. It also includes examples of motivational strategies used to motivate students in developing the necessary English skills.

PST2E23: 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 Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15260; alm195@pitt.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

PST2E24: 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 Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15217; alm195@pitt.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

PST2E25: 5-5:45 p.m. Foothold Principles for Teaching Physics

Poster – Nicole Ruszkay, University of Maryland, College Park, 1312 Toll Physics Building, College Park, MD 20742; nruszkay@terpmail.umd.edu*

Chandra A. Turpen, University of Maryland, College Park

Fall 2013 LA Cohort, University of Maryland, College Park

Physics educators are all familiar with laws or guiding principles in physics. When we were students in innovative introductory physics and biology courses, we developed a deep understanding of the guiding principles of physics and came to value such frameworks for reasoning about the world. When we began making sense of teaching as Learning Assistants at Maryland, we decided that we should have a similar set of guiding principles for our teaching. In this presentation, we will share the set of consensus "foothold" principles that we iteratively developed for guiding our teaching practice including: 1) Don't give students the solution, help them to get it themselves; 2) Know the materials you are going to teach, but be willing to admit when you don't know; 3) Notice where your students are coming from; 4) Make learning a social/dialogic activity; and 5) Build personal connections with your students.

*Sponsored by Chandra Turpen

PST2E26: 5:45-6:30 p.m. PhysPort: Supporting Physics Teaching with Research-based Resources

Poster – Sarah McKagan, American Association of Physics Teachers, 1810 E Republican St., #7 Seattle, WA 98112; sam.mckagan@gmail.com

Physics education researchers have created research results, teaching methods, curricula, and assessments that can dramatically improve physics education. PhysPort (www.physport.org) is a one-stop shopping place for ordinary physics faculty to find resources for research-based teaching and assessment. First released in 2011 as the PER User's Guide, PhysPort has undergone re-branding, redesign, and expansion, including many new resources: overviews of over 50 research-based teaching methods and over 40 research-based assessment instruments, Expert Recommendations, the Virtual New Faculty Workshop, the Periscope collection of video-based TA training and faculty professional development materials, and the Assessment Data Explorer, an interactive tool for faculty to get instant analysis and visualization of their students' responses to research-based assessment instruments including the FCI, BEMA, and CLASS, and compare their results to national averages and students like theirs. The development of PhysPort includes research to determine faculty needs and usability testing to ensure that we meet those needs.

PST2E27: 5-5:45 p.m. How Physics Tutorials Activate Student Metacognition and Facilitate the Use of Argumentation

Poster – Ozden Sengul, Georgia State University, 1 Park Pl., Atlanta, GA 30302-3999; osengul1@student.gsu.edu

Laura Kiepura, Josh Von Korff, Georgia State University

At Georgia State University, we have initiated a collaborative research study with two other universities to explore successful instructional strategies for the implementation of studio physics in the algebra-based physics classes. As part of this study, we are interested in the basic features that are present in research-based course materials and their impacts on the development of students' metacognitive knowledge. We looked for the specific features of research-based physics tutorials from the literature and did content analysis in order to explore how tutorials helped non-major students develop metacognitive skills and utilize argumentation while working in small group work activities. We analyzed transcriptions of video-recordings of seven small group work discussions to identify students' metacognitive behaviors and understand how these behaviors are associated with the use of argumentation and students' learning.

PST2E28: 5:45-6:30 p.m. If Energy Is Always Conserved, Then Why Do We Care About Saving It?*

Poster – Abigail R. Daane, Seattle Pacific University, 3307 3rd Ave. West, Seattle, WA 98119; daanea@spu.edu

Amy D. Robertson, Lezlie S. DeWater, Seattle Pacific University

"Sociopolitical energy" (the energy used to generate electricity, run automobiles, etc.) and "physics energy" are not typically connected in K-12 and university education. Physics energy is conserved; the same quantity of energy exists at the end of any process as at the beginning. Sociopolitical energy is used up; it becomes unavailable for use in performing the same tasks again. We asked learners (5th, 9th, and 12th grade students, as well as pre-service and in-service teachers) to answer the question, "If energy is always conserved, then why do we care about saving it?" We analyzed learner responses about the relationship between these two apparently disconnected concepts and argue that learner ideas are resources for learning about the principle of energy conservation.

*This material is based upon work supported by the National Science Foundation under Grants No. 0822342 and 1222732.

PST2E29: 5-5:45 p.m. Influence of Elementary School Students' Everyday Experiences on Heat Concepts

Poster – Hyunjung Kang, Seoul National University of Education, 501ho, 46, Sangdo-ro 37-gil, Dongjak-gu Seoul, 156-031 South Korea; bkshj01@sen.go.kr

Youngseok Jhun, Seoul National University of Education

There are many studies examining how everyday experiences influence the formation of students' scientific concepts. However, current studies investigating how and what everyday experiences influence the formation of concepts regarding thermal phenomena are insufficient. We aimed to determine the kinds of activities that either help students form accurate thermodynamic concepts, or hinder their construction. We were also curious as to whether students' textbooks reflected experiences that were familiar to them. We therefore investigated fifth grade students' experiences with thermal phenomena, and analyzed the relationships of those experiences to associated science concepts, by developing a questionnaire about scientific phenomena, students' everyday experiences, and the connection between these two. From students' responses to these questionnaires, we determined the features of everyday experiences that were useful for students' understanding of scientific concepts. We also evaluated students' science textbooks to determine whether they made use of explanations of phenomena that were easy to understand.

PST2E30: 5:45-6:30 p.m. Investigating Student Difficulties with Dirac Notation

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

Emily Marshman, University of Pittsburgh

Quantum mechanics is challenging even for advanced undergraduate and graduate students. Dirac notation is a convenient notation used extensively in quantum mechanics. We have been investigating the difficulties that the advanced undergraduate and graduate students have with Dirac notation. We administered written free response and multiple-choice questions to students and also conducted semi-structured individual interviews with 23 students using a think-aloud protocol to obtain a better understanding of the rationale behind their responses. We find that many students struggle with Dirac notation and they are not consistent in using this notation across various questions in a given test. In particular, whether they answer questions involving Dirac notation correctly or not is context dependent. We thank the National Science Foundation for support.

PST2E31: 5-5:45 p.m. Investigating Student Difficulties with Time Dependence of 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

Quantum mechanics is challenging even for advanced undergraduate and graduate students. In the Schrödinger representation, the wave function evolves in time according to the Time-Dependent Schrödinger Equation. The time dependence of the wave function gives rise to time dependence of the expectation value of observables. We have been exploring the difficulties that advanced undergraduate and graduate students have with time dependence of expectation values in quantum mechanics. We have developed and administered conceptual free response and multiple-choice questions to students to investigate these difficulties. We also interviewed 23 students individually using a think-aloud protocol to obtain a better understanding of the rationale behind students' written responses. We find that many students struggle with time dependence of expectation values of observables. We discuss some findings. We thank the National Science Foundation for support.

PST2E32: 5:45-6:30 p.m. Mathematical Bottlenecks in Solving Physics Synthesis Problems*

Poster – Lin Ding, Department of Teaching and Learning, The Ohio State University, 1945 N. High St., Columbus, OH 43210-1172; ding.65@osu.edu

Bashirah Ibrahim, Daniel White, Ryan Badeau, Andrew Heckler, The Ohio State University

Differing from textbook-like single-concept exercises, synthesis problems require students to coordinate and apply multiple concepts in concert to reach a successful solution. This means that students need to have a sufficient mastery of individual concepts, be able to recognize their relevance to the task at hand, and be able to jointly apply such concepts. In an effort to empirically identify and remediate students' difficulties at these key steps, we find that mathematical complexity, inherent in quantitative problems, is yet another possible bottleneck that hinders students' success in tackling synthesis problems. A study was conducted, containing three student groups, each of which solved one version of a problem involving the same set of physics concepts but at different levels of mathematical complexity. Although the three groups performed similarly in their application of physics concepts, their approaches to handling math equations (substitution/isolation of variables) differed consistently with the complexity level.

*The study is supported by NSF DRL-1252399.

PST2E33: 5-5:45 p.m. New Electricity and Magnetism Assessment for General Physics

Poster – Michele McColgan, Siena College, 515 Loudon Rd., Loudonville, NY 12211; mmccolgan@siena.edu

Rose Finn, Darren Broder, Siena College

A new 30-question conceptual electricity and magnetism assessment for the freshman physics sequence was developed at Siena College. The assessment went through several iterations. Student pre- and post- results over several years were used to adjust the wording of questions and the question difficulty. The assessment and student normalized results are presented.

PST2E34: 5:45-6:30 p.m. Online Concept Inventories: How Easy Is it to Cheat?

Poster – Patrick Kelley, Purdue University, 309 Holiday Sq. F-9, Seymour, IN 47274; patrikelley@gmail.com

Andrew Hirsch, Rebecca Lindell, Purdue University

As part of a larger study investigating the equivalency of out-of-class use of online concept inventories to in-class use of pencil/ paper versions of the same concept inventory, we began studying how easy it is for students to cheat on an online concept inventory. As part of this study, we invited two groups of students to take an online version of the FCI. With the first group of students, we encouraged them to look up the answers online in an unproctored environment. The second group of students completed the online version of the FCI in a proctored environment. For both groups, we collected data on how long it took students to answer each question, as well as keeping track of any different websites they visited to obtain the answers. We were able to determine this by using monitoring software to monitor students' activities while taking the online concept inventories.

PST2E35: 5-5:45 p.m. Outcome of Exposure to Advanced Topics in General Physics Classes

Poster – Sunil Dehipawala, Queensborough Community College, CUNY 222-05 56th Ave., Bayside, NY 11364; sdehipawala@qcc.cuny.edu

Vazgen Shekoyan, Queensborough Community College CUNY

The variation of science interest and general performance by physics students due to exposure to advanced topics in physics were studied. Two sections of the same physics course were taught by the same instructor. Students in one section participated in group study of advanced material. Another section of the same course was taught with traditional lectures. Both groups were taught identical physics concepts each week. Course objectives of both groups were assessed by quizzes, exams, and concept inventories (FCI), as well as student assessment of learning gains (SALG) and science learning attitude (CLASS) surveys. At the end of the semester, the understanding of basic physics, problem solving skills, attitudes towards physics and science interest levels of both groups were compared to determine whether exposing students to more advanced physics with real-life applications can help improve students' basic physics knowledge, interest, and attitude towards physics.

PST2E36: 5:45-6:30 p.m. Further Investigations into the Effectiveness of Collaborative Group Exams

Poster – Joss Ives, University of British Columbia, 6224 Agricultural Rd., Vancouver, BC V6T 1Z4 Canada; joss@phas.ubc.ca

I will report on two years of results of a study designed to measure the effectiveness of an instructional strategy known as two-stage exams or collaborative group exams. This exam format first has the students take the exam individually. Once all the students have handed in their individual exams, they organize into collaborative groups of three or four and take the same exam again with only a single copy of the exam being given to each group. Different versions of the group exam feature different subsets of the questions from the individual exam. Questions isomorphic to the exam questions were administered on the end-of-course diagnostic and comparisons, using the relevant isomorphic question, are made between the students that saw a given question on the group exam and those that did not.

PST2E37: 5-5:45 p.m. Preparation for Future Learning: Troubleshooting or Problem Solving? Findings

Poster – Edit Menuha Yerushalmi, Weizmann Institute for Science, 234 Herzl St., Department of Science Teaching, Rehovot, Israel 76100; edit.yerushalmi@weizmann.ac.il

Sawsan Ailabouni, Weizmann Institute for Science

Rafi Safadi, Weizmann Institute for Science, The Academic Arab College for Education

Troubleshooting activities engage students in diagnosing/explaining embedded mistakes in teacher-made erroneous solutions for physics problems. We hypothesized that students engaged in troubleshooting activities (aided by principle-based prompts and sample diagnoses when reviewing their own diagnoses) would outperform students engaged in problem-solving activities (aided by sample solutions when reviewing their own solutions) in their preparation for future learning: understanding of the concepts required to solve these problems, as well as inclination to self-repair one's understanding when reviewing his/her work. We will describe the findings of a comparison between two groups of 10th graders from the Arab sector in Israel, one performing troubleshooting activities and the other problem-solving activities in the context of geometrical optics We will present an analysis of students' articulations that manifest self-repair when reviewing their own work, aided by instructors' diagnosis of an erroneous solution as well as analysis their performance on transfer problems.

PST2E38: 5:45-6:30 p.m. Preparation for Future Learning: Troubleshooting or Problem Solving? Methodology

Poster – Sawsan S. Ailabouni, Weizmann Institute for Science, 234 Herzl St., Department of Science Teaching, Rehovot, Israel 76100; Sawsan.ailabouni@weizmann.ac.il

Rafi Safadi Weizmann, Institute for Science, The Academic Arab College for Education

Edit Yerushalmi, Weizmann Institute for Science

Troubleshooting activities engage students in diagnosing/explaining embedded mistakes in teacher-made erroneous solutions for physics problems. We hypothesized that students engaged in troubleshooting activities (aided by principle-based prompts and sample diagnoses when reviewing their own diagnoses) would outperform students engaged in problem-solving activities (aided by sample solutions when reviewing their own solutions) in their preparation for future learning: understanding of the concepts required to solve these problems, as well as inclination to self-repair one's understanding when reviewing his/her work. We will describe the methodology used to examine this hypothesis, comparing two groups participating in on-line year-long interventions, a troubleshooting and a problem-solving intervention, both focused on the same problems. Students' performance before and after the interventions were examined using the double transfer methodology: Solving a transfer problem after studying a learning resource: instructors' diagnosis and correction of an erroneous solution to an isomorphic problem.

PST2E39: 5-5:45 p.m. Preparing Students for Physics-Intensive Careers in Optics and Photonics

Poster – Benjamin M. Zwickl, Rochester Institute of Technology, 84 Lomb Memorial Dr., Rochester, NY 14623-5603; benjamin.m.zwickl@rit.edu

Kelly N. Martin, Javier Olivera, Rochester Institute of Technology

Initial results will be described from an ongoing study that is investigating both academic and industrial career paths in optics and photonics. By grounding the discussion of workforce development in education research, we can have more productive discussions and a more accurate understanding of contentious topics such as skills gaps, shortages of skilled STEM workers, and similarities and differences between academic and industrial careers. The study is refining our understanding of the broad skills needed for success and how specific math, physics, and communication skills are utilized in academic and industrial labs. The information should inform physics departments seeking to link their curriculum with students' future careers and serve as a case study for linking physics education research with national priorities in workforce development.

PST2E40: 5:45-6:30 p.m. Probing Students' Understanding of Sizes and Distances in the Universe

Poster – Vinesh Rajpaul, University of Oxford Merton College, Oxford, Oxfordshire OX1 4JD United Kingdom; vinesh.rajpaul@merton.ox.ac.uk

Christine Lindstrom, Morten Brendehaug, Oslo and Akershus University College

Megan C. Engel, University of Oxford

The Introductory Astronomy Questionnaire (IAQ) was translated into Norwegian and given in modified form to (i) 42 pre-service science teachers at the largest teacher-education institution in Norway, before and after instruction of an astronomy module, and (ii) 922 high-school students at different schools in Oslo, the Norwegian capital, 557 of them age 12-13 (before instruction of a physics/astronomy module), and 435 of them age 14-15 (post instruction). This poster presents a ranking task that probed students' understanding of sizes and distances in the universe, along with detailed results. Unexpected findings include significant fractions of high-school students – both before and after instruction – thinking that the radius of the Earth is smaller than the height of the Earth's atmosphere (>55%), that the Pole star is contained within the Solar System (>60%), and that planets are larger than stars (>40%). The pre-service teachers fared better pre-instruction, and also showed more significant gains post-instruction.

PST2E41: 5-5:45 p.m. Reforming Introductory Physics and Chemistry Sequences at a Large Research University through Interdepartmental Collaborations

Poster – Ameya S. Kolarkar, Auburn University, 313 Allison Laboratory Auburn, AL 36849-5606; kolarkar@auburn.edu

Stuart Loch, Lynn Mandeltort, Raj Chaudhury, Auburn University

The Physics and Chemistry departments at Auburn University are collaborating on a number of levels related to reformed instruction in the introductory sequence. Interdisciplinary STEM education ideas are being introduced through collaborative in-class lessons and a co-designed Learning Assistants program is being implemented. Collaborative lessons help students see the inter-connectedness between the STEM courses that they previously saw as isolated from one another, while the Learning Assistants from their own and other connected disciplines facilitate these transformations. These reforms have been situated both in active group learning spaces built in the SCALE-UP model, as well as traditional large lecture halls. Another experiment conducted related to student learning in physics courses is the "student-sourcing" of exam problems in which students create their own exam problems. Preliminary findings indicated that those students involved in creating their own problems showed greater improvement than the rest of the class on the student-sourced exams. They also showed higher performance on the non-student-sourced final exam.

PST2E42: 5:45-6:30 p.m. Researching Ourselves: How Are We Helping Faculty to Change their Teaching?

Poster – Alice Olmstead, University of Maryland, Department of Astronomy, 1113 Physical Sciences Complex, College Park, MD 20742-2421; aolmstead@astro.umd.edu

Chandra Turpen, University of Maryland-College Park

Edward E. Prather, University of Arizona; Steward Observatory

Faculty professional development (PD) workshops are a primary mechanism used to increase the adoption and adaptation of research-based instructional strategies (RBIS). PD workshops draw in many physics and astronomy instructors and serve a critical role in changing instructional practices within our community. Our research focuses on two of the largest and longest-running workshops for faculty: the New Physics and Astronomy Faculty Workshop and the Center for Astronomy Education Teaching Excellence Workshop. We are developing a real-time professional development observation tool to document what happens during workshops. We reveal opportunities to improve these PD efforts through increased awareness of instructors' experiences and prior knowledge. We assume that all instructors have some pedagogical ideas that align with education research results, their "productive resources." We analyze interviews to demonstrate the nature of these resources and consider how different PD practices create different opportunities for instructors' resources to be built on.

PST2E43: 5-5:45 p.m. Students Reading a Physics Textbook: Evidence from Eye Tracking

Poster – Marina Malysheva, Rutgers University, 10 Seminary Pl., New Brunswick, NJ 08901; malyshev@rutgers.edu

Robert C. Zisk, Eugenia Etkina, Rutgers University

The ability to read and comprehend scientific texts is important for students. The interrogation method, a question-based reading strategy, was developed to help students to learn and perfect this ability. We use this method in a reformed introductory physics course at Rutgers University. The students are presented with text-based questions as part of their weekly homework, as well as exams. They are prompted to read a section of the textbook and write a short essay explaining why a particular scientific assertion is true (or false). We use eye-tracking technology to explore students' behavior and attention when they work on this task. This study investigates the strategies employed by students, the differences in their reading patterns, and their attention to different parts of the text. We present the results of our analysis of the data, and discuss the implications for development of effective learning material.

PST2E44: 5:45-6:30 p.m. Students' Engagement in Modes of Collaboration While Solving Problems in Groups

Poster – Alanna Pawlak, Michigan State University, 567 Wilson Rd., East Lansing, MI 48823; pawlakal@msu.edu

Marcos Caballero, Paul W. Irving, Michigan State University

Group work is becoming increasingly common in introductory physics classrooms. Understanding how students engage in these group learning environments is important for designing and facilitating productive learning opportunities for students. We conducted an exploratory study in which we collected video of groups of introductory physics students working on conceptual electricity and magnetism problems. In this setting, students must negotiate a common understanding and coordinate group decisions in order to complete the activity successfully. We observed students engaging in several distinct modes of collaboration while solving these problems. Closer analysis of these observations has been focused on identifying these different modes of collaboration and articulating what defines each one. We present preliminary analysis of a small number of videos that will inform future work, including identifying new modes and determining how different modes may be related.

PST2E45: 5-5:45 p.m. Students' Explanations of the Dirac Delta Function During Group Problem-Solving

Poster – Leanne Doughty, Michigan State University, 567 Wilson Rd., East Lansing, MI 48824-1046; ldoughty@msu.edu

Marcos D. Caballero, Michigan State University

Upper-division physics courses require the use of sophisticated mathematics. In introductory physics, studies have shown that students often lack conceptual understanding of calculus concepts and struggle to implement calculus tools. Research into students' understanding and use of mathematics in upper-level courses is in its early stages. To further this research, we have observed students engaged in group problem-solving during weekly recitation sessions for an upper-division electricity and magnetism course. Early in the course, one task required students to use a Dirac delta function (DDF) to write an expression for the charge density on the surface of a charged hollow cylinder. We report on two group discussions where different students gave a variety of explanations about the purpose of a

DDF in this context. By examining these explanations, we can determine the types of understanding students' have about DDFs and which are most productive for their use in physics contexts.

PST2E46: 5:45-6:30 p.m. Studying the Complex Roles in a Multi-Institution Collaboration to Prepare Future Physics Teachers*

Poster – Mel S. Sabella, Chicago State University, Department of Chemistry and Physics, 9501 S. King Dr., SCI 309, Chicago, IL 60628; msabella@csu.edu

Andrea G. Van Duzor, Brian Geiss, Chicago State University

Diverse constituents in the physics education and science education community bring unique expertise to the preparation of future physics teachers. The PhysTEC Project centered at Chicago State University has engaged Two Year College (TYC) faculty and high school teachers as leaders in these efforts and has developed a joint effort with supportive faculty that are interested in common themes around physics education and preparing future teachers. These relationships were developed through informal lunchtime meetings, collaborative grant proposals, co-attendance at local and national conferences, and a multi-institutional Learning Assistant Program. Interviews with participating faculty suggest a diverse set of roles that they develop in the context of the project: consumer-collaborator, reciprocal collaborator, collaborator for building curriculum and resources, collaborator for informing about diversity, and collaborator for enhancing academic presence. In this poster we describe these roles and discuss how they can inform the development and sustainability of different types of partnerships.

*Supported by the NSF (0833251) and the American Physical Society (PhysTEC)

PST2E47: 5-5:45 p.m. Teachers' Pedagogical Decisions When Facing Gaps in Content Knowledge

Poster – Gregory D. Kranich, University of Maine, 307 Husson Ave., Apt I, Bangor, ME 04401; gregory.kranich@maine.edu

Michael Wittmann, Carolina Alvarado, University of Maine

As part of the Maine Physical Sciences Partnership (NSF #0962805), we have studied a group of middle school teachers' modifications of curriculum materials, and their developing of common assessments for measuring student understanding. A team of teachers has made modifications to problematic areas of a force and motion unit, placing a new emphasis on a conceptual development of ideas that were found to be missing, specifically uniform and non-uniform motion. We observe a shared discomfort with the concept of acceleration, the implications of its sign, an inherent coordinate system choice, and whether an object is speeding up or slowing down. In this talk, I will discuss how teachers' ideas about the sign of acceleration affected their choices for planned instruction and assessment of student understanding.

PST2E48: 5:45-6:30 p.m. The Challenge of Helping Students Learn: How Too Much Scaffolding Can Hinder Performance on Representational Consistency*

Poster – Alexandru Maries, University of Pittsburgh, 4200 Fifth Ave., Pittsburgh, PA 15217; alm195@pitt.edu

Shih-Yin Lin

Chandralekha Singh, University of Pittsburgh

Prior research suggests that introductory physics students have difficulty with graphing and interpreting graphs. Here, we discuss their difficulties in translating between mathematical and graphical representations and the effect of increasing levels of scaffolding on students' representational consistency for a problem in electrostatics. Ninety-five students in calculus-based introductory physics were given a typical problem that can be solved using Gauss's law involving a spherically symmetric charge distribution in which they were asked to write a mathematical expression for the electric field in various regions and then plot the electric field. A preliminary small-scale study indicated that students have great difficulty in plotting the electric field as a function of the distance from the center of the sphere consistent with the mathematical expressions in various regions, and interviews with students suggested that what partly accounts for this difficulty is not understanding that the electric field is a piece-wise defined function with different behaviors in different regions. Therefore, two scaffolding interventions with levels of support which built on each other (i.e., the second level built on the first) were implemented in order to help them. The comparison group was not given any scaffolding support. Analysis of the student performance with different levels of scaffolding reveals that scaffolding from an expert perspective beyond a certain level may hinder students' performance and they may not even discern the relevance of the additional support. We provide possible interpretations of these findings based on in-depth interviews with some students.

*Work supported by the National Science Foundation.

PST2E49: 5-5:45 p.m. Word Problems and Student Commitment to Solving Them

Poster – A. E. Tabor-Morris, Georgian Court University, 900 Lakewood Ave., Lakewood, NJ 08701-2697; tabormorris@georgian.edu

Rebecca Schiele, Georgian Court University

In mathematics classes, students are often heard to complain about word problems. Mathematics teachers then sometimes even feel guilty about "torturing" students with these types of problems. Yet problems in real-life situations, that is, the types of situations that students are most likely to encounter in life, are almost always in the format of word problems, with information issued verbally or in a written format. Word problems are essentially the only type of problem presented in physics assignments. Based on the literature, types and creation method factors from a mathematics teaching point of view are presented. Discussion is made and suggestions for applications of these ideas in the creation of physics word problems.

PST2E50: 5:45-6:30 p.m. The Pedagogical Value of Conceptual Metaphor for Secondary Science Teachers*

Poster – Abigail R. Daane, Seattle Pacific University, 3307 3rd Ave. West, Seattle, WA 98119; daanea@spu.edu

Jesper Haglund, Uppsala University

Amy D. Robertson, Rachel E. Scherr, Seattle Pacific University

Hunter Close, Texas State University

The abstract nature of energy encourages the use of metaphorical language in educational settings. K-12 teachers and students use conceptual metaphors implicitly to express their ideas about what energy is or how it functions in particular scenarios. Attending to the use of conceptual metaphors in the classroom can expand teachers' repertoire for formative assessment of student ideas. Yet science education research on analogies and metaphors has predominately focused on explicit, instructional analogies, rather than attending to such implicit, ubiquitous features of natural language in science. In a secondary science teacher professional development course, we observe teachers engage in an instructional activity designed to increase awareness of conceptual metaphor in everyday language and in descriptions of energy. These teachers come to value the application of conceptual metaphor in educational settings; they acknowledge that if they identify metaphors present in their students' science language, they will better understand their students' ideas about energy. We present possible mechanisms for teacher growth in learning and valuing the use of energy metaphors and illustrate how to support teachers in noticing, understanding, and valuing metaphors for energy.

*This material is based upon work supported by the National Science Foundation under Grants No. 0822342 and 1222732.

PST2E51: 5-5:45 p.m. Traditional Physics Versus IPLS: Comparing Student Interest and Engagement*

*Poster – Tessa E. Williams,** Swarthmore College, 500 College Ave., Swarthmore, PA 19081; twilliia4@swarthmore.edu*

Benjamin Geller, K. Ann Renninger, Catherine H. Crouch, Swarthmore College

Chandra Turpen, University of Maryland

Swarthmore College life science students take a traditional first semester physics course, but have the option of taking an innovative Introductory Physics for the Life Sciences (IPLS) course in the second semester. This curricular structure presents a unique opportunity to compare students' experiences across these different instructional environments. We have used multiple conceptual and attitudinal survey instruments, and have interviewed a number of students over the course of the year, in an effort to assess students' evolving relationship with physics across these two different experiences. In this talk we present some of our findings from these survey and interview data, comparing epistemological and affective features of students' experiences across the traditional and IPLS environments. This comparison allows us to identify some of the features that students find especially engaging about the IPLS course in particular.

*Work supported in part by Swarthmore College and by the Howard Hughes Medical Institute Science Education Grant to Swarthmore College. **Sponsored by Catherine Crouch

PST2E52: 5:45-6:30 p.m. Unpacking the Source of Student Interest in an IPLS Course

Poster – Benjamin Geller, Swarthmore College, 500 College Ave., Swarthmore, PA 19081; bgeller1@swarthmore.edu

Chandra Turpen, University of Maryland, College Park

Ann Renninger, Panchompoo Wisittanawat, Catherine Crouch, Swarthmore College

Effectively teaching an Introductory Physics for the Life Sciences (IPLS) course means engaging life science students in a subject for which they may not have considerable preexisting interest. We have found that the inclusion of authentic life science examples supports students whose initial interest in physics is less developed, but that different examples and models vary in their effectiveness at engaging student interest. In this talk we begin to unpack this variability, exploring why some life science examples may be more successful than others at sparking and sustaining student interest. By analyzing data from (1) survey instruments assessing student interest in particular life science examples, and (2) interviews conducted with students before and after instruction, we identify features of our IPLS course that appear to be particularly important for fostering student engagement. We suggest that some of these features might also foster student interest in more traditional introductory physics courses.

PST2E53: 5-5:45 p.m. Utilizing Informal Science Programs to Understand and Promote Connections Between Physics Identity and Racial Identity*

Poster – Simone A. Hyater-Adams, University of Colorado, Boulder, 2030 Athens St., Apt C1-V, Boulder, CO 80302-0001; simone.hyateradams@colorado.edu

Noah Finkelstein, Katie Hinko, University of Colorado, Boulder

The mission to increase diversity in STEM fields has been taken up by many outreach programs across the country, especially in the physical sciences. A common structure of these programs involves dominant members of the field attempting to reach out to populations in non dominant cultures, and few if any studies have been done to determine the impacts of this approach. These programs may be improved given an understanding of how cultural backgrounds affect a student's ability to identify as a scientist. Using an established research-based informal science program at the University of Colorado Boulder, Partnerships for Informal Science Education in the Community (PISEC), we are conducting studies to explore the possible connections and disconnections between students' cultural backgrounds and their identification as physicists. Integrating the work of Zahra Hazari on student Physics Identity and Na'ilah Nasir on Racialized Identities in learning environments, we offer a conceptual lens to examine the relationship between racial and physics identities. Through a process of reviewing the program and documenting its capacity to develop a student's interest and identity in science, we create a preliminary framework to examine the identity negotiations of students of color in informal physics learning environments.

*NSF #1423496

PST2E54: 5:45-6:30 p.m. What Are Students Learning in Your Lab Class? A New Tool to Find Out

Poster – Natasha G. Holmes, Stanford University, 382 Via Pueblo Mall, Stanford, CA 94305-1684; ngholmes@stanford.edu

Carl E Wieman, Stanford University

The AAPT recently endorsed a set of goals for physics laboratory curriculum. These goals, which focus on six skill-based areas, were published as guidelines and recommendations for developing laboratory curricula. I will present recent work on developing and validating an easily used test of these skills, a lab concept inventory. The test focuses on aspects of modeling and constructing knowledge, with emphasis on evaluating a physical model in light of measured data. I hope this poster will elicit feedback and input to help tailor the test to the needs of the community.

Wednesday, July 29 Highlights

REGISTRATION:
8 a.m.–3 p.m. SSU - Foyer

H.S. Physics Photo Contest Winners Posted

Committee Meetings, 7–8:30 a.m.
–Awards Marriott - 0101
–Finance Marriott - 2111/2110
–Programs II Marriott - 0105

MILLIKAN MEDAL: ROBERT A. MORSE:
10:30–11:30 a.m. SSU - Hoff Theater

Committee Meetings, 11:30 a.m.–12:45 p.m.
–Membership & Benefits SSU - Pyon Su
–SI Units & Metric Education SSU - Charles Carroll A

Topical Discussion Sessions, 11:30 a.m.–1 p.m.
AAPT Governance Change II SSU - Charles Carroll B
iOS and Android App Show SSU - J. R. Jimenez
PERTG Town Hall SSU - B. Banneker B
Physics on the Road SSU - B. Banneker A

Poster Session (Post-deadline):
1–2:30 p.m. SSU - Grand Ballroom Lounge

Great Book Giveaway:
3–3:30 p.m. Stamp Student Union Foyer

Session FA: Effecting Change Using PER

Location: SSU - Benjamin Banneker B
Sponsor: AAPT
Date: Wednesday, July 29
Time: 8:30–10:30 a.m.

Presider: Gina Quan

FA01: 8:30–8:40 a.m. How to Approach and Sustain Department-level Introductory Teaching Reform

Contributed – Raluca E. Teodorescu, The George Washington University, 725 21st St., NW, Washington, DC 20052-0002; rteodore@gwu.edu

Gerald Feldman, Mark Reeves, Carol O'Donnell, Larry Medsker, The George Washington University

The Department of Physics at GWU started to reform the introductory physics and astronomy courses in active-learning format in 2008. These changes have been informed by the SCALE-UP pedagogy and targeted both algebra-based and calculus-based physics courses, as well as astronomy courses. As of last year, all of our introductory physics courses are now delivered in SCALE-UP mode, and half of our introductory astronomy courses follow that format as well. These courses are taught by 15 faculty assisted by 11 graduate teaching assistants (GTAs), accommodating about 600 students per semester. The transformation involved faculty at all levels (tenured, tenure-track and part-time), as well as GTAs and undergraduate Learning Assistants. We will describe the critical implementation elements of our approach and the infrastructure that was created to sustain the reform. In addition, we will present several assessments with the most impact on long-term changes of faculty attitudes towards the adoption of evidence-based teaching methods.

FA02: 8:40-8:50 a.m. Designing Educational Innovations for Sustained Adoption*

Contributed – Charles Henderson, Western Michigan University, Kalamazoo, MI 49008-5252; charles.henderson@wmich.edu

Renee Cole, University of Iowa

Jeff Froyd, Texas A&M University

Debra Gilbuena, Oregon State University

Raina Khatri, Western Michigan University

Efforts to improve undergraduate STEM education have generated many great ideas, but few have propagated widely. Propagation, not innovation, is a critical problem in higher education. To help education developers address sustained adoption, we have created a How-To Guide. The guide is based on our collective experiences studying and attempting to create educational change. This includes: a) an understanding current practice based on our analysis of 75 grant proposals funded by the NSF CCLI program in 2009, and b) an understanding of effective practices based on identifying and characterizing a set of instructional strategies and materials that have propagated. We also draw heavily on literature on change from a variety of perspectives, including studies on educational change, organizational change, social psychology, and diffusion of innovations. This talk will introduce core ideas from the How-To Guide.

*Supported, in part, by NSF#1122446.

FA03: 8:50-9 a.m. Evaluating Student Scores for the FCI Administered a Month or More after the End of the Course

Contributed – Michele McColgan, Siena College ,515 Loudon Rd., Loudonville, NY 12211; mmccolgan@siena.edu

Students took the FCI again at the start of the second semester of our general physics course. Normalized results are compared with the FCI results at the end of the first semester. Results are compared for our calculus-based courses and algebra-based courses with both IE and traditional instructors.

FA04: 9-9:10 a.m. Meta-Analysis of Student Learning in Mechanics: A Fifty-Thousand Student Study

Contributed – Benjamin Archibeque, Developing Scholars Program, Office of Undergraduate and Creative Inquiry, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; esayre@gmail.com*

Eleanor C. Sayre, Kansas State University

Joshua Von Korff, Georgia State University

Sarah B. McKagan, American Association of Physics Teachers

Measuring the effectiveness of various classroom aspects across universities is an ongoing problem for physics educators and education researchers. A common method is to administer research-based conceptual inventories, the Force and Motion Conceptual Evaluation (FMCE) and the Force Concept Inventory (FCI), to students, and compare these results to their peers in other classes. We conducted a secondary analysis of all peer-reviewed papers which publish data from U.S. and U.S.-like colleges and universities, including over 50,000 students in approximately 100 papers. We ran statistical analysis between classroom data, like SAT scores, math level, and pedagogy, and institution data from the Carnegie Classifications, to see what impacts student learning. We found that while teaching method is important, it is not the only factor that influences student learning.

*Sponsored by Eleanor Sayre

FA05: 9:10-9:20 a.m. Study Behavior and Performance in Introductory Physics

Contributed – John C. Stewart, West Virginia University, 135 Willey St., Morgantown, WV 26501; jcstewart1@mail.wvu.edu

This talk examines the degree to which the study behaviors students select and the amount of time spent on those behaviors affect performance in calculus-based introductory physics. Ten years of class performance data from a large public university is combined with self-reported time-on-task and study behavior data collected using survey instruments. As has been reported in other disciplines, the degree to which students turn in required assignments is a key factor affecting success; however, little correlation is found with the amount of time reported completing those assignments and class success. Differences in reported behavior patterns between students with different levels of success in the class are examined. Clusters of students with similar behavior patterns are identified and characterized.

FA06: 9:20-9:30 a.m. Transformative Experience as a Construct for Understanding Attitudinal Changes in Introductory Physics Classes

Contributed – David Donnelly, Texas State University, 601 University Dr., San Marcos, TX 78666; donnelly@txstate.edu

Eleanor W. Close, Hunter G. Close, Texas State University

Recent results assessing changes in students' attitudes in a general education physics class have suggested that students have undergone a transformative experience.[1] The construct of transformative experience has previously been used in assessing student attitudes in different introductory courses.[2] We will discuss the Transformative Experience construct, and how we feel it is applicable to the attitudinal data we have. We will also present data that have been collected to assess the prevalence of transformative experiences in an introductory calculus based physics class, and ideas of class activities that might foster transformative experiences.

1. Pugh, K., Educational Psychologist, 46, 107 (2011), "Transformative Experience: An Integrative Construct in the Spirit of Deweyan Pragmatism"

2. Frank, B., & Atkins, L. (2013, July 17-18). Adapting Transformative Experience Surveys to Undergraduate Physics. Paper presented at Physics Education Research Conference 2013, Portland, OR

FA07: 9:30-9:40 a.m. Aspects of PCK in a Physics Class for Future Teachers*

Contributed – Claudia Fracchiolla. Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506 ;fracchiollac@ksu.edu

N. Sanjay Rebello, Bahar Modir, Kansas State University

Since Shulman (1986) introduced the concept of PCK it has been a hot topic of research in the education community. Magnusson, et al. (1999) suggested five aspects of PCK that could be developed in teacher training programs. One of those aspects is knowledge of kids' ideas. A physics course for future elementary teachers at Kansas State University looks to integrate the process of learning the physics concepts with learning of kids' ideas about those concepts and determining if changes in future teachers' knowledge of kids' ideas are observable throughout the semester. As part of the requirements of the class, future teachers created micro-lessons of the topics they were learning. We analyzed these micro-lessons through the semester to determine if there were observable changes in the future teachers' knowledge of kids' ideas.

*Supported in part by NSF grant 1140855

FA08: 9:40-9:50 a.m. Pedagogical Modalities of University Physics Students in an After-school Program

Contributed – Kathleen A. Hinko, University of Colorado Boulder, 440 UCB, Boulder, CO 80309-0001; kathleen.hinko@colorado.edu

Peter Madigan, Eric Miller, Noah D. Finkelstein, University of Colorado Boulder

Physicists have a tradition of teaching physics in informal environments; however, pedagogical practices in these settings have not been widely studied, despite their potential to provide insight into formal practices. We investigate interactions between children and university physics students in an after-school program facilitated by the University of Colorado Boulder. In this program, undergraduates, graduate students and post-docs work with K-8 children on hands-on physics activities on a weekly basis over the course of a semester. We use an Activity Theoretic framework to examine individuals' behavior in video data from the program. From this analysis, we identify three main pedagogical modalities displayed during activities: Instruction, Consultation and Participation. These modes are characterized by certain uses of language, physical location, and scientific objectives that establish differences in roles, division of labor, and community. Based on this analysis, we discuss implications for promoting pedagogical strategies through curriculum development and university educator preparation.

FA09: 9:50-10 a.m. National Learning Outcome Study of Learning Assistant (LA) Supported Classes

Contributed – Ben Van Dusen, CU Boulder, 990 37th St., Boulder, CO 80309-0001; benjamin.vandusen@colorado.edu

Laurie Langdon, Valerie Otero, CU Boulder

This study investigates the effects of various uses of Learning Assistants (LAs) on student outcomes across 13 LA Alliance member institutions. Over 4,500 students and 29 instructors participated in the study. The Force and Motion Concept Evaluation (FMCE) and the Brief Electricity and Magnetism Assessment (BEMA) and others were used in 32 different classes across the U.S. Our analysis links course-level information (e.g. how LAs are utilized) and average LA-student interaction time to course learning gains. We will report results from various institutional settings and discuss contextual effects on student outcomes within the disciplines of physics, biology, chemistry, and calculus.

FA10: 10-10:10 a.m. Faculty Online Learning Communities to Support Physics Teaching

Contributed – Andy R. Rundquist, Hamline University, 1536 Hewitt Ave., MS B1807, St. Paul, MN 55104-1284; arundquist@hamline.edu

Melissa Dancy, Joel Corbo, University of Colorado

Charles Henderson, Western Michigan University

Sandy Martinuk

In conjunction with the Physics and Astronomy New Faculty Workshops, we are investigating mechanisms to further support new faculty in improving their teaching. Previous work indicates that many faculty return from the workshop excited and attempt to integrate workshop ideas into their teaching. Unfortunately, many struggle and slowly revert back to traditional instruction. Further, participants have requested ongoing support for their teaching efforts. We are investigating ways to provide such support by offering a Faculty Online Learning Community (FOLC) with a subset of workshop participants. The FOLC has a goal of supporting self-reflective teachers in a way that is sustainable. We have used several communities as models, including the Math/Twitter Blog-o-sphere and the Global Physics Department. We have also done research on the best uses of technology for communication. This talk will focus on results from our initial FOLC experience and plans for future FOLC offerings.

FA11: 10:10-10:20 a.m. Trade-offs in Pursuing PER-inspired Versus Traditional Goals in Introductory Physics

Contributed – Andrew R. Elby, University of Maryland, College Park, TLPL, Benjamin Bldg., College Park, MD; 20742-1115 elby@umd.edu

Eric Kuo, Stanford University

Ayush Gupta, University of Maryland, College Park

Michael Hull, Wayne State College

Historically, physics education researchers sometimes faced skepticism from physics faculty about the benefits of PER-based materials and pedagogy. Perhaps partly for this reason, we have sometimes been hesitant to discuss potential instructional trade-offs. Almost every PER study that explores both traditional and PER-inspired goals reports that the targeted result, typically conceptual gains, does "not" come at the expense of performance on standard quantitative problems. In this study of a first-semester physics course for engineers, we compare a novice instructor who emphasized the PER-inspired goal of mathematical sense-making to an experienced instructor who emphasized "traditional" problem solving. On the shared final exam, the novice instructor's students displayed better mathematical sense-making but the experienced instructor's students performed better on standard problems. We use these results to raise the hypothesis that, at least for novice instructors, courses can't always "have it all"; tough choices must be debated and made between different instructional goals.

FA12: 10:20-10:30 a.m. Assessment of Evidence-based Physics Instruction*

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

A primary challenge for physics educators for over 100 years has been how best to assess the level of students' achievement of instructors' learning goals. There has been a gradual evolution of thinking and much research has been done, but there is still only limited consensus on optimum methods for evaluating learning of physics. I will discuss some of the approaches that have been taken to address key issues such as multiple learning goals, logistical and practical constraints, and the complexity of students' mental models.

*Supported in part by NSF DUE #1256333

Session FB: K-12 PER II

Location: SSU - Charles Carroll A
Sponsor: AAPT
Date: Wednesday, July 29
Time: 8:30–10:10 a.m.

Presider: Dan Crowe

FB01: 8:30-8:40 a.m. Resource-based Item Response Curves

Contributed – Alexander M. Axthelm, University of Maine, 214 Bennett Hall, Orono, ME 04469; alexander.axthelm@maine.edu

Michael C Wittmann, Carolina Alvarado Leyva, Laura Millay, University of Maine

As part of a larger project to study middle school teachers' knowledge of their students' ideas, the Maine Physical Sciences Partnership (NSF #0962805) has developed a multiple-choice survey on energy that has been administered to thousands of students. We analyze our results using a modified version of Item Response Theory which does not focus on correctness of answers but instead focuses on the ideas that students use when choosing their answers. In this talk, I will present a coding scheme which goes beyond the "correct/incorrect" paradigm, and looks at the possible lines of thought that could lead a student to a particular response. By comparing ideas used across many questions, we can conclude which resources are most productive for students. I use these results to describe productive student reasoning about energy on this survey.

FB02: 8:40-8:50 a.m. Consequences of Teachers' Content Difficulties on Planned Instruction and Assessment

Contributed – Gregory D. Kranich, University of Maine, 307 Husson Ave., Apt. I, Bangor, ME 04401; gregory.kranich@maine.edu

Michael Wittmann, Carolina Alvarado, University of Maine

As part of the Maine Physical Sciences Partnership (NSF #0962805), we have studied a group of middle school teachers' modifications of curriculum materials, and their developing of common assessments for measuring student understanding. A team of teachers has made modifications to problematic areas of a force and motion unit, placing a new emphasis on a conceptual development of ideas that were found to be missing, specifically uniform and non-uniform motion. We observe a shared discomfort with the concept of acceleration, the implications of its sign, an inherent coordinate system choice, and whether an object is speeding up or slowing down. In this talk, I will discuss how teachers' ideas about the sign of acceleration affected their choices for planned instruction and assessment of student understanding.

FB03: 8:50-9 a.m. Debating One Conceptual Question Throughout a Unit: Benefits and Reflections

Contributed– Colleen G. Nyeggen, Lick-Wilmerding High School, 755 Ocean Ave., San Francisco, CA 94112; colleen.nyeggen@gmail.com

High School physics teachers often use conceptual questions at the beginning of a unit, to elicit students' prior understandings or motivate the topic, or at the end of a unit to apply concepts already learned. In this talk, I discuss how a sufficiently rich conceptual question can be productively revisited throughout a unit, serving as the subject for an ongoing, whole-class debate. Revisiting a well-chosen question multiple times allows students to: (a) Refine their own intuitions and experiences as they construct explanations; (b) Engage in scientific practices such as asking questions, developing models, engaging in argumentation, and evaluating information; (c) Rethink their own ideas continuously in light of new evidence and others' reasoning; and (d) Recognize and reflect on whole-class progress in understanding. I will show evidence of high school students engaging in these behaviors and share strategies for using this process in any physics unit.

FB04: 9-9:10 a.m. Interactive Whiteboard: A Catalyst for Student Use of Gestures

Contributed – Bor Gregorcic, University of Ljubljana, Jadranska 19 Ljubljana, 1000 Slovenia; bor.gregorcic@fmf.uni-lj.si

Eugenia Etkina, Rutgers University

Gorazd Planinsic, University of Ljubljana

In a qualitative study we have observed and analyzed the interactions of small groups of high school students who collaboratively investigated orbital motion in a gravitational field using a virtual experiment on an interactive whiteboard. We have observed that during the activity, students communicated not only by talking, but that an important part of the communication was through body and hand gestures. In the talk, we will show how using gestures in combination with spoken language helped students express complex ideas and communicate them to other students without the need for using advanced vocabulary that students were still not familiar with. Student use of gestures can be encouraged by providing them with an appropriate content, environment, and tools for inquiry.

FB05: 9:10-9:20 a.m. "Am I Stealing Your Glory?" – Supporting Students' Agency During Discussions

Contributed – Enrique A. Suarez, University of Colorado, Boulder, 249 UCB, Boulder, CO 80309-0249 CO; enrique.suarez@colorado.edu

Valerie Otero, University of Colorado, Boulder

Discussions, whether in small or large groups, are one of the cornerstones of learning through engaging in scientific disciplinary practices. They provide opportunities for teachers to explore student understanding, and for students to co-construct physics principles from evidence-supported claims. However, it is not always obvious how to best facilitate these discussions in a way that supports students' epistemic agency. The PER study reported here explores teachers' moves during consensus discussions while implementing the Physics and Everyday Thinking (PET) curriculum. Teacher moves were analyzed for how they promote or constrain students' participation in dialogic discourse. We will discuss specific moves that supported and enhanced student discourse, as well as moves that derailed rich student thinking and conversations. Finally, we propose strategies based on this research for facilitating discussions and pitfalls teachers may want to avoid.

FB06: 9:20-9:30 a.m. Developing Teaching Materials that Work

Contributed – Martin Richard Hopf. University of Vienna, Austrian Educational Competence Centre, Physics, Lorenz-Kellner-Gasse, 20 Vienna, 1220; martin.hopf@univie.ac.at

For several years now, the PER Group in Vienna, Austria, has been working on the development of teaching materials for high school physics teaching. Our main focus is to construct materials that work. For this we rely on a cyclic process of construction, evaluation, re-construction etc. Part of this research is to identify explanations of physics concepts that are accepted by students. So far, ready-to-use materials exist on teaching Newton's mechanics in 7th grade[1] and on geometrical optics.[2] Also draft materials exist for infrared and ultraviolet radiation, special relativity, electromagnetic fields and particle theory. In the talk a short overview on the research agenda is given. The main focus will be the presentation of the teaching materials for mechanics and research results regarding their use in classrooms.

1. Hopf, M.; Wilhelm, Th.; Tobias, V.; Waltner, Chr. & Wiesner, H. (2011): Promoting students' understanding of Newtonian mechanics through an alternative content structure – Results from an empirical study. Paper presented at the ESERA 2011.

2. Haagen-Schützenhöfer, C. (2014). The relevance of students' conceptions for teaching geometrical optics in practice. Paper presented at ICPE 2013.

FB07: 9:30-9:40 a.m. Energy – Momentum – Force – Kinematics: Redesigning the High School Mechanics Curriculum

Contributed – Alexander Robinson, Thornapple Kellogg High School, 13836 Hardenburg, Trl Eagle, MI 48822; thegreatmongoose@gmail.com*

Alicia C. Alonzo, James Brian Hancock II, Michigan State University

While much of the early research on "misconceptions" focused on the rationality of these ideas, current physics curriculum materials and assessments emphasizing well-documented "misconceptions" about mechanics seek to "root out" students' intuitive ideas and to replace them with the correct scientific ones. Yet by the time students enter high school physics classrooms, these ideas have worked well in over a decade of experience interacting with moving objects. Thus, over the past three years, we have engaged in iterative cycles of curriculum design research, exploring whether we can leverage (rather than root out and replace) students' intuitive ideas about motion by reversing the order in which mechanics topics are typically taught in high school physics. Drawing on classroom videos, weekly video-recorded student cognitive interviews, and student responses to a multiple-choice diagnostic assessment administered five times each semester, we describe how student thinking develops using our redesigned curriculum.

*Sponsored by Alicia Alonzo.

FB08: 9:40-9:50 a.m. Putting the Puzzle Pieces Together: Teachers' Reasoning About Student Thinking

Contributed – Alicia C. Alonzo, Michigan State University, 620 Farm Lane Blvd., Room 307, East Lansing, MI 48824; alonzo@msu.edu

Andrew Elby, University of Maryland

Learning progressions (LPs) – descriptions of increasingly sophisticated ways of thinking – are influencing materials for teachers. Underlying much of this work is a strong, though often tacit, assumption that students' conceptual thinking is theory-like and context-independent. Yet theoretical perspectives (e.g., naïve conceptions, knowledge-in-pieces) and empirical evidence suggest more fragmented models of student thinking. Interested in this potential mismatch, we explored how high school physics teachers reasoned about student thinking when presented with LP-based diagnostic information. While teachers were able to make sense of the LP perspective, they tended to treat student thinking about force and motion as less coherent. Each teacher switched among several different perspectives to interpret the information provided, with variation in the amount of structure they attributed to the "pieces" comprising understanding of force and motion. We consider how these results can inform LP-based professional development that leverages teachers' multiple perspectives about student cognition.

FB09: 9:50-10 a.m. Classical Physics Learning from Analysis of Modern Physics Data

Contributed – Kenneth W. Cecire, University of Notre Dame, Department of Physics, Notre Dame, IN 46556; kcecire@nd.edu

Deborah M. Roudebush, Oakton High School

Many of the classical physics principles we teach are hundreds of years old. So, unfortunately, are many of the examples we use. However, these same principles apply - and are vital - in research at the frontiers of physics. For example, conservation of momentum and energy are necessary to understand the products of particle collisions in the Large Hadron Collider. The authors make a first attempt to determine if students are more motivated to learn about classical principles through activities which employ authentic data from current, cutting-edge experiments. They also seek to determine if such activities enhance learning of classical topics in the physics canon.

FB10: 10-10:10 a.m. Searching Possibility of Integrated Education with Science and Mathematics

Contributed – Youngseok Jhun, Seoul National University of Education, 1650 SeochoGu Seochodong Seoul, 137-742, South Korea; jhunys@snue.ac.kr

Hana Jung, Seoul National University of Education

National science curriculum of Korea is divided into four fields: Physics, Chemistry, Biology, and Earth Science. It has been said that the students have more difficulty in learning physics than the other fields, and "The Speed of Objects" rank the most difficult classes. One of the biggest causes of the difficulty is related with the mathematics. Students have to draw graphs which they are not skilled well in the classes of mathematics. Many students also have difficulty in calculating objects' speed. It seems that students need a mathematical background for studying these classes. However, we have different ideas; Learning Science can help learning mathematics, instead of "learning mathematics is necessary for studying science." Students may learn mathematics easily when they deal with the context of the real world. We designed a strategy to teach mathematics additionally in science classes on "The Speed of Objects," and we examined the leaning process of the students.

Session FC: MOOCs Go to High School

Location: SSU - Charles Carroll B
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Physics in High Schools
Date: Wednesday, July 29
Time: 8:30–10:30 a.m.

Presider: Wolfgang Christian

FC01: 8:30-9 a.m. Teaching AP Physics 1 to the World

Invited – Andrew Duffy, Boston University, Department of Physics, 590 Commonwealth Ave., Boston, MA 02215; aduffy@bu.edu

This spring, Boston University (BU) led the edX course titled Preparing for the AP Physics 1 Exam. The course team included members of BU's Department of Physics (including our teacher-in-residence) as well as several Boston-area high school teachers, supported by edX platform experts at BU's Digital Learning Initiative. The nature of the material made it a good introductory physics class, so it attracted students of all ages, from a wide variety of backgrounds. Given that some fraction of the students had a goal in mind (to take the AP Physics 1 test), we were hopeful that the dropout rate would not be as dramatic as in most MOOCs. We will report on those numbers, the experience of running a 16-week physics course aimed at high school students, as well as on how we implemented lab experiments in the online environment, which included labs based on Peter Bohacek's direct-measurement videos.

FC02: 9-9:30 a.m. Online Blended-Learning Units for AP Teachers and Students*

Invited – Larry Cain, Davidson College, Box 6919, Davidson, NC 28035-6919; lacain@davidson.edu

Davidson College, in collaboration with the College Board and edX, is creating online, blended-learning units to enhance student mastery of AP Physics. The project—known as Davidson Next—follows a deliberate process of design and development to ensure its effectiveness. We selected topics by reviewing past AP exam data regarding challenging concepts. Content was created by college and high school physics instructors with many years of experience developing and grading AP exams. The units are consistent with best practices in blending online and in-class teaching and learning—they feature video lectures, interactive activities, and formative and summative assessment tools. The physics materials (available—for free—in late summer 2015) have been tested using a group of 10 AP physics instructors and over 400 AP physics students. We will discuss the design process, the pilot program's results, and other aspects of Davidson Next.

* Funded by a grant from The Laura and John Arnold Foundation

FC03: 9:30–10 a.m. GeorgetownX Goes to High School: AP Physics C: E&M

Invited – Dedra Demaree, Georgetown University, 3520 Prospect St. NW, #314, Arlington, VA 22209; dd817@georgetown.edu

Yong Li, Yianna Vovides,Georgetown University

Georgetown University (GU) has been producing MOOCs for two years through our Center for New Designs in Learning and Scholarship (CNDLS). Our MOOC titled "Preparing for the AP Physics C: Electricity and Magnetism Exam" addresses introductory electricity and magnetism topics (using calculus) from a standpoint of continually asking "how do we know," using experimental evidence, conceptual logic, derivation, and application of equations. In this MOOC, students were exposed to how these topics relate to research at GU and undergraduate GU student perspectives. Teachers who took this MOOC were also exposed to the pedagogical choices made and resources for use in their own classrooms. For each MOOC CNDLS administers for GeorgetownX, we ask students to take assessment surveys based on the Community of Inquiry framework for online learning. This talk will discuss how we designed this particular MOOC as well as our research findings across the GeorgetownX experience.

FC04: 10-10:30 a.m. 8.MechCx: Transforming an Existing MOOC into a High School Oriented MOOC

Invited – Christopher Chudzicki, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139-4307; chudzick@mit.edu

Boris Korsunsky, Weston High School

Peter Bohacek, ISD 197

Zhongzhou Chen, Dave E. Prichard, Massachusetts Institute of Technology

As part of the edX High School Initiative, the RELATE Group at MIT transformed our previous introductory physics MOOC 8.MReVx: Mechanics Review (taken previously by many high school teachers) into 8.MechCx: Advanced Introductory Classical Mechanics, a new course at the level of AP Physics C: Mechanics. In order to make the course more suitable for high school students and match the AP Physics C: Mechanics curriculum at the same time, we made various modifications to our existing course, including the creation of a series of video-based interactive lab activities. In this talk, I will discuss the pedagogical approach taken in our course, the design and implementation of lab activities for our MOOC, and cover some of the interesting aspects of the basic demographics of the course, such as the of ratio of actual high school students vs. high school physics teachers among both registered students and certificate earners. In addition, I will also briefly talk about the some of the controlled learning experiments that conducted in this course.

Session FD: ADVANCE Grants: Increasing the Participation of Women in Physics

Location: SSU - Juan Ramon Jimenez
Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on Professional Concerns
Date: Wednesday, July 29
Time: 8:30–10:10 a.m.

Presider: Geraldine Cochran

FD01: 8:30-9 a.m. ADVANCE: Increasing the Participation and Advancement of Women in Academia

Invited – Jessie A. DeAro, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230; jdearo@nsf.gov*

The goal of the National Science Foundation's ADVANCE program is to increase the representation and advancement of women in academic science and engineering careers. The NSF has invested over $200 M since 2001 to support ADVANCE projects at more than 150 different institutions of higher education. ADVANCE Institutional Transformation (IT) projects are the longest running and largest investments in organizational change at institutions of higher education. IT awards are designed to address the organizational and cultural barriers at universities and colleges that negatively impact the participation and advancement of women in STEM academics and leadership. IT strategies include: educating and empowering decision-makers; work-life policies; career support programs; and tenure and promotion policy review, revision and clarification. This talk will present some of the lessons learned from the investments in ADVANCE and discuss some of the continuing challenges for achieving gender equity in the STEM academic workforce.

*Sponsored by Geraldine L. Cochran

FD02: 9-9:30 a.m. From 'Fixing Women' to 'Institutional Transformation': An ADVANCE Case Study

Invited – Sherry J. Yennello, Texas A&M University, 3366 TAMU, College Station, TX 77843-3366; yennello@comp.tamu.edu*

Christine L. Kaunas, Texas A&M University

The United States' position in the global economy requires an influx of women into science, technology, engineering, and mathematics (STEM) fields in order to remain competitive. Despite this, the representation of women in STEM continues to be low. The National Science Foundation's

ADVANCE Program addresses this issue by funding projects that aim to increase the representation of women in academic STEM fields through transformation of institutional structures that impede women's progress. This paper includes a case study of the Texas A&M University ADVANCE Program, which broadly illustrates the multifaceted process of organizational change within STEM academia.

*Sponsored by Geraldine Cochran

FD03: 9:30-10 a.m. WISe Initiatives to Support Women Faculty in STEM

Invited – Lea V. Michel, Rochester Institute of Technology, 85 Lomb Memorial Dr., Rochester, NY 14623-5603; lvmsch@rit.edu

Kara Maki, Rochester Institute of Technology

When a school is given an NSF Advancement of Women in Academic Science and Engineering Careers (ADVANCE) grant, one expects to see bold new initiatives that result in broad institutional change. However, institutional change takes time and requires sweeping support from administration at every level. So, realistically, what can be accomplished with an ADVANCE grant? The Women in Science (WISe) program at the Rochester Institute of Technology (RIT), encouraged and supported by RIT's ADVANCE team, has decided to focus on several key issues which can hinder women faculty in STEM from achieving success: the work-life balance, fewer leadership opportunities, and the general lack of institutional awareness of gender bias. We have developed several WISe initiatives to help address these imbalances at RIT with the goal of sparking long-term institutional change.

FD04: 10-10:10 a.m. ADVANCE: The Lasting Impact of Mutual Mentoring*

Contributed – 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

A 2007 NSF-ADVANCE project invited us to participate in a mutual mentoring network for senior women physics faculty at small liberal arts colleges. We found it so useful, that we have continued meeting (via Skype) every two weeks well after the formal project (and grant funding) ended. We will discuss the reasons why we found it so successful as well as the proposal we have developed to share this project with other women faculty in physics through AAPT.

*Partial support provided by NSF Grant HRD-0619150: "Collaborative Research for Horizontal Mentoring Alliances," Kerry Karukstis, PI.

Session FE: PER: Exploring Problem Solving Approaches and Skills

Location: SSU - Margaret Brent A/B
Sponsor: AAPT
Date: Wednesday, July 29
Time: 8:40–10:30 a.m.

Presider: Andrew Boudreaux

FE02: 8:40-8:50 a.m. Student Epistemologies and Resource Use in a Conceptual Physics Problem

Contributed – Tyler D. Scott, Northwestern College, 101 7th St. SW, Orange City, IA 51041; tyler.scott@nwciowa.edu

Catherine McGough, Lisa Benson, Clemson University

A significant goal of STEM education research has been to understand how students solve problems. An important aspect of students' approaches to problem solving is their epistemologies, or beliefs about knowledge. In this study, students in a calculus-based, introductory physics course were presented with a problem on a test that asked them to find the mass of a simple pendulum given its equation of motion. Later, students were asked to write a short reflection on their problem-solving strategies and feelings as they wrestled with the problem. Understandably, students were frustrated by their inability to obtain a numerical answer. Reflections and test answers give insight into the students' beliefs about the complexity and source of knowledge. Results show that most students relied heavily on their equation sheets. However, frustration with that method led some to progress to other considerations including lab experiences and their own conceptual understanding.

FE03: 8:50-9 a.m. Concept Recognition as a Bottleneck in Solving Synthesis Problems

Contributed – Daniel R. White, The Ohio State University, 191 West Woodruff Ave., Columbus, OH 43210-1168; drwhite@mps.ohio-state.edu

Ryan Badeau, Lin Ding, Andrew F. Heckler, The Ohio State University

Improving students' skills in solving synthesis problems, which are problems requiring the application of multiple concepts such as energy conservation and kinematics, is typically a key instructional goal. We have previously found that students struggle with synthesis problems more than their single-concept counterparts in part because of difficulty recognizing all the relevant concepts or that multiple concepts are needed. Here we report on an experiment designed to test the effects of different types of hints on helping students apply the necessary concepts in solving a problem combining energy conservation and centripetal acceleration. While we found no statistically significant differences between the effects of different hints, we discuss trends suggesting that discouraging common incorrect solution paths may be more effective than highlighting underused components of a correct solution.

FE04: 9-9:10 a.m. Preparation for Future Learning: Troubleshooting or Problem Solving? Methodology

Contributed – Sawsan S. Ailabouni, Weizmann Institute of Science, 234 Herzl St., Department of Science Teaching, Rehovot, Israel 76100; Sawsan.ailabouni@weizmann.ac.il

Rafi Safadi, Weizmann Institute of Science, The Academic Arab College for Education

Edit Yerushalmi, Weizmann Institute of Science

Troubleshooting activities engage students in diagnosing/explaining embedded mistakes in teacher-made erroneous solutions for physics problems. We hypothesized that students engaged in troubleshooting activities (aided by principle-based prompts and sample diagnoses when reviewing their own diagnoses) would outperform students engaged in problem-solving activities (aided by sample solutions when reviewing their own solutions) in their preparation for future learning: understanding of the concepts required to solve these problems, as well as inclination to self-repair one's understanding when reviewing his/her work. We will describe the methodology used to examine this hypothesis, comparing two groups participating in online year-long interventions, a troubleshooting and a problem-solving intervention, both focused on the same problems. Students' performance before and after the interventions were examined using the double transfer methodology: Solving a transfer problem after studying a learning resource: instructors' diagnosis and correction of an erroneous solution to an isomorphic problem.

FE05: 9:10-9:20 a.m. Preparation for Future Learning: Troubleshooting or Problem Solving? Findings

Contributed – Edit Menuha Yerushalmi, Weizmann Institute of Science, 234 Herzl St., Department of Science Teaching, Rehovot, Israel 76100; edit.yerushalmi@weizmann.ac.il

Sawsan Ailabouni, Weizmann Institute of Science

Rafi Safadi, Weizmann Institute of Science, The Academic Arab College for Education

Troubleshooting activities engage students in diagnosing/explaining embedded mistakes in teacher-made erroneous solutions for physics problems. We hypothesized that students engaged in troubleshooting activities (aided by principle-based prompts and sample diagnoses when reviewing their own diagnoses) would outperform students engaged in problem-solving activities (aided by sample solutions when reviewing their own solutions) in their preparation for future learning: understanding of the concepts required to solve these problems, as well as inclination to self-repair one's understanding when reviewing his/her work. We will describe the findings of a comparison between two groups of 10th graders from the Arab sector in Israel, one performing troubleshooting activities and the other problem-solving activities in the context of geometrical optics. We will present an analysis of students' articulations that manifest self-repair when reviewing their own work, aided by instructors' diagnosis of an erroneous solution as well as analysis of their performance on transfer problems.

FE06: 9:20-9:30 a.m. Synthesis Problem Solving: Concept Recognition and Application*

Contributed – Bashirah Ibrahim, Department of Teaching and Learning, The Ohio State University, 1945 N. High St., Columbus, OH 43210-1172; BASHIRAH2001@GMAIL.COM

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

Daniel White, Ryan Badeau, Andrew Heckler, The Ohio State University

The study explores the effects of incrementing the mathematical complexity of a synthesis problem on students' ability to recognize the relevant concepts and appropriately apply the identified concepts. The task highlights the situation of a block propelled from a spring on an inclined ramp. It undergoes projectile motion and lands on another inclined surface. Three versions of the task with different mathematical complexity were designed, requesting for the horizontal distance traveled by the block, spring compression, and projection angle respectively. A cohort of 105 physics students in three groups completed one version of the problem. Across the three tasks, more than a half of the sample succeeded in recognizing the appropriate concepts and committed to using solely the identified concepts. However, regardless of the mathematical complexity level, the majority of the students failed to correctly apply the physics concepts, with the occurrence of similar types of conceptual mistakes.

*The study is supported by NSF DRL-1252399.

FE07: 9:30-9:40 a.m. Effect of Multimedia Hints on Students' Visual Attention*

Contributed – Xian Wu, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506; xian@phys.ksu.edu

Bahar Modir, John Hutson, Lester C. Loschky, N. S. Rebello, Kansas State University

To create valuable hints in computer-assisted instruction for physics problems involving graphs and figures, the effect of hint modalities needs to be tested on students' performance and visual attention. Participants in our study solved four sets of conceptual problems, each of them containing one initial problem, six training problems, one near transfer problem, and one far transfer problem. The data showed that the same content in different modalities alters the effectiveness of the hint. Students' eye movement data has also been explored to give insight into how hint modality changes students' visual attention and how multiple hint modalities interact with each other. The results of this study could shed light on generating new principles to guide construction of computer-based physics problem solving instruction.

*This research is supported in part by the U.S. National Science Foundation under Grants 1138697 and 1348857. Opinions expressed are those of the authors and not necessarily those of the Foundation.

FE08: 9:40-9:50 a.m. Effect of Visual Cues and Display Design on Problem Solving*

Contributed – Bahar Modir, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; bahar@phys.ksu.edu

Xian Wu, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Previous studies have shown that visual cues can help students to shift their attention toward relevant features of the conceptual physics problems in graph representation. However cueing does not completely prohibit students from attending to irrelevant features of a problem. In this study with students in an algebra-based class, we investigated the role of cues based on Wickens' proximity compatibility principle that enabled us to adapt cues to particular kinds of questions. This principle states that there is a competition between the proximity of display features and proximity between the information in the mental state of the participants. Further, based on the Gestalt laws of grouping, we manipulated the display design to investigate the influence of the display proximity on the organization of the students' attention toward the relevant parts of a problem and how that affects their response time.

*Supported in part by the National Science Foundation Grant 1348857

FE09: 9:50-10 a.m. Effects of Visual Cues and Video Solutions on Conceptual Tasks*

Contributed – Tianlong Zu, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; zutianlong@gmail.com

Elise Agra, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Visual cueing is shown to be effective in helping students solve conceptual physics tasks. However, students may have difficulties in solving physics transfer tasks with different surface features. We investigated if instruction provided using videos that contain explanations to the tasks that will improve students' performance in solving near and far tasks. We interviewed students using a think-aloud protocol. Each interview included four sets of tasks. In each set students need to solve one initial problem, four isomorphic training tasks, a near transfer task, and a far transfer task. Based on the conditions, some of the students were provided with visual cues when solving training tasks, and some of them were provided with an instructional video following the training session. We compare students' reasoning patterns and correctness in the two conditions.

*Supported in part by NSF Grant 1348857.

FE10: 10-10:10 a.m. Investigating Problem Solving Automaticity Using Eye Movements*

Contributed – Elise Agra, Kansas State University, Department of Physics, 116 Cardwell Hall, Manhattan, KS 66506; esgagra@gmail.com

Tianlong Zu, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Visual cues have been shown to direct attention to relevant areas of a diagram and facilitate problem solving. We investigate the effect of visual cues on students' visual attention while solving conceptual physics problems with diagrams. The diagrams contained features relevant to correctly solving the problem, as well as features attributed to common incorrect answers. Students enrolled in an introductory mechanics course were individually interviewed using a think-aloud protocol while their eye movements were recorded. Participants worked through four sets of problems containing an initial problem, four isomorphic training problems, and two transfer problems. Students in the cued condition saw visual cues overlaid on the training problems. A second interview was conducted two weeks later, in which students solved the two transfer problems without cues. We compare the cued and non-cued groups with respect to the automaticity of extracting relevant information on the transfer and retention problems.

*This material is based upon work supported by the National Science Foundation under Grant Nos. 1138697 and 1348857.

FE11: 10:10-10:20 a.m. Some Unintended Consequences of Prompting Students to Construct Force Diagrams

Contributed – Luke D. Conlin, Stanford University, 1919 Cooley Ave. East, Palo Alto, CA 94303; luke.conlin@gmail.com

Nicole Hallinen, Eric Kuo, Stanford University

As physics instructors, we often scaffold problem solving by prompting students with a series of intermediate steps. The consequences, good or bad, of such scaffolding are often left uninvestigated. We report on results of a study partially replicating and extending research by Heckler (2009) in which we asked undergraduate students to solve Newton's laws problems. Half of the students were prompted to draw a force diagram before finding a solution. We found that the diagram prompt drove students away from an intuitive strategy, toward more lengthy formal strategies with lower success rates. In another measure, students were more likely to find fault with the informal nature of an intuitive solution if the problem statement included a diagram prompt. These results suggest that such problem-solving scaffolding affects students' solution approach, possibly by cuing different epistemological stances on what counts as a good answer.

FE12: 10:20-10:30 a.m. Students' Use of Representations in Modeling Instruction Introductory Physics

Contributed – Daryl McPadden, Florida International University, 11200 SW 8th St., Miami, FL 33199; dmcpa001@fiu.edu

Eric Brewe, Geoff Potvin, Florida International University

We present the preliminary results of a study of student use of representations in problem solving within the Modeling Instruction – Electricity and Magnetism (MI-EM) course. Representational competence is a critical skill needed for students to develop a sophisticated understanding of and success in college science topics. In this study, 70 students were given a survey of 25 physics problem statements both pre- and post- instruction, covering both Newtonian Mechanics and Electricity and Magnetism (EM), and asked which representations they would use in that given situation. We analyze the results by comparing the preponderance of these representations. We also compare student representation use for those who had already taken the first-semester Modeling Instruction Mechanics course and those students who had taken a non-Modeling Mechanics course. In addition, we look at how students representation use changed by context of problem (Mechanics vs. EM).

Session FF: Publishing Physics Textbooks: Old and New

Location: SSU - Pyon Su
Sponsor: Committee on the Interests of Senior Physicists
Co-Sponsor: Committee on History and Philosophy in Physics
Date: Wednesday, July 29
Time: 8:30–10:10 a.m.

Presider: David Cook

FF01: 8:30-9 a.m. The Evolution of a Modern Textbook

Invited – Brian Jones, Colorado State University, Physics Department, Fort Collins, CO 80523; physicsjones@gmail.com

I am a co-author on Knight, Jones, Field *College Physics*, now in its 3rd edition. I'll describe the development of the first edition from Knight's *Physics for Scientists and Engineers* and the changes in subsequent editions. We started with a clear vision and an understanding of what we wanted to accomplish. Since the start, the book has evolved in response to our experiences using the materials with students. The book has also been shaped by what faculty and students say they want, as well as how faculty and students actually use the book. These changes have led to a book that is better adapted to its environment. Future evolution will be driven by trends in education and in electronics.

FF02: 9-9:30 a.m. The Process of Publishing: From Submitted Manuscript to Marketed Product

Invited – Jeanne Zalesky, Editor in Chief, Physical Sciences, Pearson Education, Boston, MA jeanne.zalesky@pearson.com

An author's submission of a manuscript to a potential publisher is only the first step in a long, careful process that leads ultimately to a published product. This talk will present broad overviews of the process by which a submitted manuscript for a print or digital product is evaluated prior to a publishing decision and of the multi-step process leading from a favorable decision through the marketing of the final product, including tips to help potential authors speed that process. Understanding that process may help authors and end users alike appreciate what goes in to setting the cost of the final product. This talk will also present a few thoughts on the future of printed text books and the extent to which electronic books may come to be more the norm.

FF03: 9:30-9:40 a.m. Self-Publishing Customizable Texts

Contributed – David M. Cook, Lawrence University, Department of Physics, 711 E Boldt Way, SPC24, Appleton, WI 54911-5699; david.m.cook@lawrence.edu

A decade ago, efforts to seek a commercial publisher for my text *Computation and Problem Solving in Undergraduate Physics* failed, primarily because the required section-by-section customization was not compatible with then-available publishing procedures, and I undertook a self-publishing venture. The required customization is, in fact, easily accomplished using LaTeX. Some of the source files contain language-independent text and IF-THEN-ELSE statements controlled by true-false flags while others contain examples specific to one or another computational tool. Once the flags have been set for the desired components, LaTeX produces a printable file for a 500-page book in five minutes. Submitted to a sophisticated copy machine, that file automatically yields collated two-sided copies at a total cost (excluding shipping but including a modest royalty) of about $30 per copy. Over 1000 copies have been sold since the self-publishing venture began. Current efforts to explore commercial publication again do not seem promising.

FF04: 9:40-9:50 a.m. Process of the Formation of Mechanics Textbooks in 19th Century England

Contributed – Koji Tsukamoto, Kashiwa-minami High School, 3-3-3 Minoridai Matsudo-shi, Chiba 270-2231, JAPAN; koji@611.jp

In most mechanics textbooks today, it is understood that the equation of motion "F = ma" as the fundamental principle of mechanics, was discovered by Newton and published as the Second Law of the three laws of motion *in Principia* (1687). The equation "F = ma", however, could not be found anywhere in *Principia*. Indeed, the system of classical mechanics, which is known as "Newtonian mechanics" today, was accomplished at the end of the 18th century after a great deal of effort was taken by scientists over a century after Newton. At that time, however, none of them correlated the fundamental principle of mechanics with Newton's three laws of motion. We present the process of the formation of mechanics textbooks in which Newton's three laws were placed in a prominent position in 19th century England.

FF05: 9:50-10 a.m. Ganot's Physics

Contributed – Thomas B. Greenslade, Kenyon College, Department of Physics, Gambier, OH 43022; greenslade@kenyon.edu

In 1852 Adolphe Ganot (1804-1887) published the first edition of his *Traité de Physique*. This book, translated into many languages, was in print for about 80 years. In the United States it was one of the most commonly used texts for the junior-level Natural Philosophy course. It used relatively little mathematics, but the text and woodcut illustrations gave a comprehensive treatment of the emerging field of physics. In addition, it was a primary reference for many fields of technology. I have nearly a dozen copies of various editions in my collection, and often use it for my research into 19th-century physics apparatus.

FF06: 10-10:10 a.m. ComPADRE Personal Publications

Contributed – Bruce A. Mason, University of Oklahoma, 440 W. Brooks St., Norman, OK 73019; bmason@ou.edu

Lyle Barbato, AAPT

Mario Belloni, Wolfgang Christian, Davidson College

ComPADRE has expanded the library's Personal Collection tools to provide an interface for the web-publication of content. The Publication Interface provides a customizable set of web pages and navigation that can be used to share curricular materials, research results, lab resources, or other materials that can be provided over the web. Published material can be hosted in the library, uploaded to personal space on ComPADRE, or linked from other hosting services in the cloud. Connections to the ComPADRE user database provides control over how and with whom content is shared. This is a service available specifically for AAPT members and subscribers to ComPADRE. Examples of the use of this interface will be demonstrated during the talk.

Session FG: Recruiting, Retaining, and Outreach to Underrepresented High School Teachers

Location: Jimenez Hall (JMZ) - 0105
Sponsor: Committee on Science Education for the Public
Co-Sponsor: Committee on Diversity in Physics
Date: Wednesday, July 29
Time: 8:30–10 a.m.

Presider: Amber Stuver

FG01: 8:30-9 a.m. Developing STEM Teachers to Serve Underrepresented Minority Students in High Poverty Urban Elementary Schools

Invited – Katya Denisova, Baltimore City Public Schools, 200 E North Ave., Rm. 303, Baltimore, MD 21202; kdenisova@gmail.com

Teacher training and support is an integral component of the STEM Achievement in Baltimore Elementary Schools (SABES) project. Funded by NSF, SABES operates in grades three to five in three under-served neighborhoods of Baltimore city. It is a multi-faceted research and outreach endeavor to understand and circumvent challenges to STEM learning, faced by kids coming from less-than-ideal learning environments. This project involves Johns Hopkins schools of Engineering, Education, and Social Sciences, as well as Baltimore City Public Schools, and community stakeholders. As one form of teacher support, we offer a Physical Science course, which is conducted by STEM Master teachers (elementary school teachers who graduated from the STEM Certificate Program at a local college) mentored and coached by a pedagogical content expert. We collected data in the form of surveys and pre-/post-tests to understand teachers' perceptions about the course and science teaching, and to measure change in teachers' content knowledge.

FG02: 9-9:30 a.m. A New Educational Paradigm and Its Impact on the Diversity of Physics Teachers

Invited – Robert Goodman, New Jersey Center for Teaching and Learning, 115 Franklin Turnpike, #203 Mahwah, NJ 07430; bgoodman33@gmail.com

States and countries are attempting to raise achievement in mathematics and science to improve social justice and international competitiveness. A new educational paradigm which began in one NJ classroom in 1999 has been shown to provide a welcoming on-ramp to STEM career pathways and has spread to more than 100 schools. Mathematically rigorous algebra-based physics is a crucial element; so scaling this solution required many new physics teachers. Drawing on physics majors would not have provided nearly enough due to their low numbers and the fact that many do not have the necessary interest, aptitudes or dispositions. Instead, the new pedagogy was used to teach physics to accomplished teachers of other subjects. This solved the shortage while increasing the diversity of physics teachers; mirroring the demographics of the teaching profession. This program has become the #1 producer of U.S. physics teachers and those teachers are 18% Black, 15% Hispanic and 47% women.

FG03: 9:30-10 a.m. Recruiting, Retaining and Outreach to Underrepresented High School Teachers

Invited – Angela M. Kelly, Stony Brook University, 106 Roland Ave., South Orange, NJ 07079; angela.kelly@stonybrook.edu

The diversification of the physics teacher population in the U.S. is a complex issue. In many undergraduate physics programs, women and underrepresented minorities comprise a relatively small proportion of prospective physics teacher candidates. Similarly, there is an underrepresentation of women and minorities among undergraduate faculty. This disparity may be problematic for students who seek role models and mentors to pursue physics study and subsequently aspire for careers in physics teaching. This presentation will share results from several interviews with female and underrepresented physics teachers in urban schools. These teachers discussed their motivations, inspirations, successes, and roadblocks during their career preparation. They also shared physics teaching experiences that highlight ways in which female and underrepresented students might be encouraged to pursue post-secondary physics study. Implications and future directions will be discussed.

Session FH: Soft Matter Labs

Location: SSU - Prince George's
Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Graduate Education in Physics
Date: Wednesday, July 29
Time: 8:30–10:20 a.m.

Presider: Gabe Spalding

FH01: 8:30-9 a.m. Stretching Rubber: An Experiment for Teaching Entropic Elasticity and Thermodynamics

Invited – Theodore A. Brzinski, NC State University, 2401 Stinson Dr., Raleigh, NC 27695-8202; tbrzins@ncsu.edu

Karen E. Daniels, NC State University

Entropy is a difficult concept to teach using real-world examples. Unlike temperature, pressure, volume, or work, it's not a quantity that most students encounter in their day-to-day lives. Even the way entropy is often qualitatively described, as a measure of disorder, can be incomplete and misleading. To address these obstacles, we have developed a laboratory activity, the stretching of an elastic rubber sheet, intended to give students hands-on experience with the concepts of entropy, temperature, and work in adiabatic and quasistatic processes. A compelling feature is that students can reproduce the qualitative behavior they experience in lab with an everyday object, a rubber band. We will present two versions of the experiment: a double-lever system, which may be reproduced with relatively little cost, and a version that uses a commercial materials testing system, and provides students experience with scientific instrumentation that is used in research.

FH02: 9-9:30 a.m. Biophysics Modules in a Final-Year Lab Course*

Invited – Nancy R. Forde, Department of Physics, Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6 Canada; nforde@sfu.ca

John Bechhoefer, Department of Physics, Simon Fraser University

We have created a fourth-year one-semester lab course for our new undergraduate major in Biological Physics, which is accessible also to students from a pure physics background and from a molecular biology background. The course aims to bridge the gap between directed and independent laboratory-based learning, while developing skills in interdisciplinary research. I will outline the learning objectives and style of the course, which combines pre-set modules in basic molecular and cell biology, spectroscopy and leading-edge biophysical techniques with independent student projects. I will then discuss in more depth one or two of the experimental modules, as selected by audience interest: optical trapping; fluorescence correlation spectroscopy (FCS); DNA electrophoresis; microscopy and directed vs. diffusive motion; light-matter interactions (absorption and fluorescence spectroscopy and light scattering). These experimental modules can easily be modified for incorporation into stand-alone laboratory courses at both the advanced and introductory undergraduate levels.

*The development of this course was facilitated by a Cottrell Scholar award to NRF from the Research Corporation.

FH03: 9:30-10 a.m. Opportunities and Challenges Arising in Advanced Experimental Physics Courses

Invited – Jonathan McCoy, Colby College, 5800 Mayflower Hill, Waterville, ME 04901-8840; jhmccoy@colby.edu

Advanced experimental physics courses, aimed at junior and senior majors, can substantially shift a student's perception of the discipline as a whole. In particular, by emphasizing open-ended, project-based learning opportunities, these courses can provide a bridge between the core curriculum and the exciting world of active research. At the same time, these courses initiate departures from a familiar world of problem sets, textbooks, and lab manuals that can be challenging for students. In this presentation I will use a newly developed Experimental Soft Matter course, taught at Colby College during the spring semester of the 2013-2014 academic year, to explore the opportunities and challenges arising in advanced experimental physics courses more generally.

FH04: 10-10:10 a.m. The Quantitative Biology Research Community (QBReC) at Brandeis

Contributed – Jerome Fung, Brandeis University, MS 057, 415 South St., Waltham, MA 02453; jfung@brandeis.edu

Stephen J. DeCamp, Timothy Harden, Charlotte F. Kelley, Joia Miller, Larry Tetone, Alyssa S. Canelli, Daniel Langenthal, Jane Kondev, Brandeis University

Standard introductory undergraduate science courses seldom address the open questions that motivate researchers at the frontier. While involving undergraduates in research can address this, it can be challenging for students to put their research in a broader scientific context. We discuss a new program at Brandeis University, the Quantitative Biology Research Community (QBReC), that works at the intersection of molecular biology, biochemistry, and soft matter physics to address these issues. At the heart of QBReC is a research laboratory course in which pairs of freshmen and sophomores do two 7-week projects mentored by a graduate student or postdoctoral associate. These projects are drawn from the mentors' research and have ranged from theoretical studies of transcription regulation to experimental studies of active matter. We discuss some of the projects, future plans for the program, and preliminary data on how the program has influenced student epistemological attitudes towards science.

FH05: 10:10-10:20 a.m. Biophysical Measurements of Cells, Microtubules, and DNA with an AFM

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

Atomic force microscopes (AFMs) are ubiquitous in biophysics and soft matter research laboratories and have recently been priced for use in undergraduate education. Here we review several AFM platforms (Dimension 3000 by Digital Instruments, EasyScan2 by Nanosurf, ezAFM by Nanomagnetics, and TKAFM by Thorlabs) and describe various soft matter experiments that could be done in the teaching laboratory using these instruments. In particular, we focus on experiments that image biological materials and quantify biophysical parameters: 1) imaging cells to determine membrane tension, 2) imaging microtubules to determine their persistence length, 3) imaging the random walk of DNA molecules to determine their contour length, and 4) imaging stretched DNA molecules to measure the tensional force.

Session FI: Tesla Coils

Location: Art-Sociology Building (ASY) - 2309
Sponsor: Committee on Apparatus
Date: Wednesday, July 29
Time: 8:30–9:30 a.m.

Presider: Sam Sampere

FI01: 8:30-9 a.m. The Making of the University of Bern Twin Tesla Coil

Invited – Urs Lauterburg, University of Bern, Physics Institute, Sidlerstrasse 5 Bern, BE 3012 Switzerland; urs.lauterburg@space.unibe.ch*

After an introduction to the basic physical principles of a Tesla coil, the presenter will walk through the stages of making a medium size twin Tesla coil assembly that makes for an impressive demonstration for students in a lecture hall environment. The presentation will discuss the specifications and the sources of the necessary electrical and mechanical components as well as the assembly of the building blocks. Finally, a description of the actually achieved performance along with several variations of characteristic demonstrations will be shown with commented pictures and short video sequences.

*Sponsored by Sam Sampere, PIRA

FI02: 9-9:30 a.m. High Voltage! Using Tesla Coils to Spark Student Engagement

Invited – Jeremy J. Benson, NIU STEM Outreach, 916 N. 12th St., De Kalb, IL 60115-2516; JJBenson@niu.edu

High-voltage displays can be particularly exciting and captivating to students and adults alike. This makes them an excellent tool for demonstrating basic and more advanced concepts in electricity and electronics. NIU STEM Outreach's Jeremy Benson will discuss how Tesla coils can be used to teach concepts including potentials, resistance, and capacitance to students at a variety of levels. The use of a computer controlled musical Tesla coil also provides additional opportunities to address concepts of acoustics and sound production as well as just being plain cool to watch!

Session FJ: Undergraduate Research and Capstone Projects II

Location: Art-Sociology Building (ASY) - 2203
Sponsor: AAPT
Date: Wednesday, July 29
Time: 8:30–10 a.m.

Presider: Aaron Titus

FJ01: 8:30-8:40 a.m. Easing Students into Undergraduate Research Projects

Contributed – Karen A. Williams, East Central University, 1020 E 6th, Ada, OK 74820; kwillims@mac.com

This presentation will describe how I have transitioned students fresh out of Physics I and II into doing a research project. Many first-generation and minority students are apprehensive about research and presentations. Some have done fine work in the lab and put together a nice poster, but back out when it comes time to stand at their poster and talk about it to others. I will discuss how I designed part of Jr Physics Lab to ease my students into research. I will also discuss the variety of research projects done by my students in lab as well as projects chosen in other programs such as McNair, Honors and Louis Stokes AMP Programs. Our small undergraduate institution lacks a huge physics department with graduate student projects to join. Some students have wide physics knowledge and others do not. Some students qualify for REU experiences but such paid opportunities for international students are rare. How do these students get a shot and succeed at the first research opportunity?

FJ02: 8:40-8:50 a.m. Investigations in Physics

Contributed – Jeffrey D. Marx, McDaniel College, 2 College Hill, Westminster, MD 21158-4100; jmarx@mcdaniel.edu

This past academic year my department implemented a new series of required upper-division, one-credit physics courses: Investigations in Physics I and II. The purpose of this sequence is to provide our majors the opportunity to propose their own question and then have the full term to explore answers to that question. During the once-per-week, hour-long meeting time, individual students give me a progress report and set goals for the following week. Students' grades in the course are based on how well they stay focused on their Investigation, the extent to which they analyze their question, a final paper, and an oral presentation to the class. In this talk I will describe the details of the course and my interactions with the students, as well as some specific Investigation questions that were proposed by our students and some of the implementation challenges I faced this past year.

FJ03: 8:50-9 a.m. Lessons Learned through Undergraduate Research Projects in Graduate-level Physics

Contributed – James M. Overduin, Towson University, Department of Physics, Astronomy & Geosciences, Towson, MD 21252-0001; joverduin@towson.edu

I report on lessons learned through supervising 10 Towson University undergraduate research students (ranging from sophomores to seniors) in projects involving astrophysics, gravitation, and relativity over the past five years. Most of these projects involved topics well outside the standard undergraduate physics curriculum. Yet most of these students were quite successful, presenting their results at an average of two scientific meetings each and co-authoring more than 20 publications in refereed journals and conference proceedings. I attempt to assess what did and didn't work. Methods that might be appropriate for graduate students, such as a lengthy immersion process of background reading, do not work. Rather, it is best to jump straight in with a concrete calculation. Deeper understanding can and usually does follow once students have attained a sense of mastery over some aspect of the subject, no matter how small. Mathematical ability is not nearly as important as many students think. Persistence is more important. But the strongest predictor of research success in undergraduate students is passion for the subject.

FJ04: 9-9:10 a.m. Thank You for Flying

Contributed – Gregory A. DiLisi, John Carroll University, 8517 Forest View Dr., Olmsted Falls, OH 44138; gdilisi@jcu.edu

We describe our flight and undergraduate research project aboard NASA's Boeing 727-200 "Weightless Wonder" aircraft, more affectionately known as "The Vomit Comet." This aircraft creates multiple periods of microgravity by conducting a series of parabolic maneuvers over the Gulf of Mexico. Our experiment examined the stability of "liquid bridges," small strands of fluid suspended between two supports, as they entered and exited microgravity. The parabolic flight method offers technical originality and provides experimental insights for researchers in the microgravity field. Here we present hardware development, experimental considerations, and results, and demonstrate that parabolic flight is a viable alternative to extant techniques for quantitative experiments on fluids.

FJ05: 9:10-9:20 a.m. On International Collaboration in Undergraduate Physics Research

Contributed – Theodore R. Halnon, 111 Kern Building, University Park, PA 16802; trh5241@psu.edu*

From May 11 to June 6, as a Penn State McNair Scholar, I participated in a course taught at Shanghai Jiao Tong University, Minhang Campus, Shanghai, China. This course, Basic Aspects of Superconductivity, was a collaborative effort between Shanghai Jiao Tong University (SJTU), The University of Illinois in Urbana-Champaign (UIUC), and The Pennsylvania State University (PSU). It was taught jointly by Nobel Laureate Professor Tony Leggett (UIUC) and Professor Ying Liu (PSU). The course combined classroom learning, supervised collaborative research between American students and Chinese students, and after-class city exploration with students from UIUC, PSU, and SJTU. In this talk, I will discuss the benefits and struggles that I faced when taking the course, when doing research with Chinese students, and while living in Shanghai. I will then discuss how my experiences during this course allowed me to grow as an academic and as a person.

*Sponsored by Mikhail Kagan

FJ06: 9:20-9:30 a.m. BIAR: A New Way to Look at the Interactions of Students and Teachers

Contributed " Elias Euler, 6669 Otis Ct., Arvada, CO 80003; eleu1908@colorado.edu*

An accurate, nuanced capturing and characterization of student/teacher behavior inside and outside the classroom is a necessity in today's education reform. In this paper, a new framework, called the BIAR (Beliefs, Intentions, Actions, and Reflections) Student-Teacher Interaction Model, is introduced. This tool incorporates the use of TDOP (Teaching Dimensions Observation Protocol) in classroom observations alongside student/faculty interviews, stimulated recall sessions, and electronic surveys. Once gathered, the data can be compared and analyzed for their degree of correlation. The analysis of BIAR data can provide specific formative feedback to both students and teachers. Running the tool on a larger scale provides motivation for institutional change and offers a more detailed rendition of today's classroom interactions.

*Sponsored by Noah Finkelstein

FJ07: 9:30-9:40 a.m. The Acoustic Impedance in Musical Instruments

Contributed – Herbert Jaeger, Miami University, Department of Physics, Oxford, OH 45056; jaegerh@MiamiOH.edu

Robert Durrough, Miami University

The acoustic impedance is defined as the ratio of pressure over the volume flow and depends strongly on the frequency. The acoustic impedance of a musical instrument gives valuable information on its acoustic response, thus measurement of acoustic impedance can reveal the behavior of an instrument. Using a piezo-buzzer and an electret microphone we constructed an impedance transducer to measure the input impedance of simple systems as well as musical instruments. Besides quantifying the acoustic impedance of air columns, this transducer serves to demonstrate properties of acoustic systems for non-major physics classes, in fact this was the original motivation for this work. The transducer is easy to build and robust, so that it is also well-suited for an undergraduate laboratory environment. In this talk we discuss the function of the impedance transducer and illustrate some of the measurements that we are undertaking as part of a physics capstone course.

FJ08: 9:40-9:50 a.m. Speed, Spin, and Shape Factor

Contributed – Mikhail Kagan, 1600 Woodland Rd., Abington, PA 19001-3918; mak411@psu.edu

While athletes have traditionally used a treadmill to get in a better physical shape, a physics teacher can use it to determine the shape factor of a rolling object. If a tired person stops walking on the treadmill, she will be moving with the same speed as the belt. At the same time, a bowling ball--being in a "worse physical shape"--would not be moving as fast. In fact, by measuring the final speed of various objects rolling on the treadmill, one can determine the objects' shape factor.

FJ09: 9:50-10 a.m. Understanding Epistemic Beliefs and Metacognition in Undergraduate Thesis Writing

Contributed – Jason E. Dowd, Duke University, Box 90338, Durham, NC 27708; jason.dowd@duke.edu

Robert J. Thompson, Julie A. Reynolds Duke University

We present results from ongoing research to better understand how metacognition, motivation, and epistemic beliefs mediate and moderate the scientific reasoning and writing skills that students exhibit through writing an undergraduate thesis. Previous work indicates that scaffolding the writing process in a thesis-writing course can be an effective strategy for promoting these skills. In such courses, we have found that implementation of an intervention focused explicitly on students' epistemic beliefs is positively related to changes in students' beliefs, as measured by pre- and post surveys. Here we further explore this and other relationships by relating observed changes to the assessment of scientific reasoning and writing skills in students' writing. Data have been collected across multiple departments and institutions over three years. Ultimately, our analysis will be used to motivate institution- and department-specific changes.

Session FK: Astronomy Education Research

Location: SSU - Benjamin Banneker A
Sponsor: AAPT
Date: Wednesday, July 29
Time: 8:30–9:30 a.m.

Presider: Doug Lombardi

FK01: 8:30-8:40 a.m. Probing Student Perspectives Using the Introductory Astronomy Questionnaire (IAQ)

Contributed – Saalih Allie, University of Cape Town, Physics Department, Rondebosch, 7701 South Africa; saalih.allie@uct.ac.za

Vinesh Rajpaul, Sarah-Louise Bly, University of Cape Town

As part of educational initiatives in the Department of Astronomy at the University of Cape Town, a written instrument, the Introductory Astronomy Questionnaire (IAQ), was developed to probe student perspectives on various aspects of physics and astronomy, along with related broader views about science such as astronomy vs. astrology, and the Big Bang as a "theory". The purpose of the instrument when used as a pre-test is to be able to map out the background characteristics of the student cohort in order to inform teaching, while as a post-test the instrument provides information about the effectiveness of the course. The present talk focuses on the structure and ambit of the IAQ, and acts as an introduction to two related talks that report on findings from studies carried out in South Africa and Norway (with pre-service teachers).

FK02: 8:40-8:50 a.m. Teacher Behavior Drops with Increasing Expertise in Pre-service Science Teachers

Contributed – Christine Lindstrom, Oslo and Akershus University College, Pilestredet 52 Oslo, Oslo NO-0130 Norway; christine.lindstrom@hioa.no

Vinesh Rajpaul, Megan Engel, University of Oxford

The Introductory Astronomy Questionnaire (IAQ) was translated into Norwegian and given in adapted form to 42 pre-service science teachers at the largest teacher education institution in Norway. The IAQ was administered before and after instruction of a 12-hour astronomy module. One question prompted students to explain the difference between astronomy and astrology and another question probed students' understanding of 'the Big Bang as a theory'. In both questions, students were asked to "write a detailed account" of what they would have said to three year-10 students discussing these topics. In the pre-test, 18 (46%) and 14 (36%) students respectively responded in a pedagogical manner, displaying a clear focus on helping students learn. The remaining answers were written in an expert voice that did not make reference to the hypothetical students. In the post-test, however, only two (5%) and five (14%) students respond as teachers and the rest as experts.

FK03: 8:50-9 a.m. Probing Students' Understanding of Sizes and Distances in the Universe

Contributed – Vinesh Rajpaul, University of Oxford, Merton College, Merton St., Oxford, Oxfordshire OX1 4JD United Kingdom; vinesh.rajpaul@merton.ox.ac.uk

Christine Lindstrom, Morten Brendehaug, Oslo and Akershus University College

Megan C. Engel, University of Oxford

The Introductory Astronomy Questionnaire (IAQ) was translated into Norwegian and given in modified form to (i) 42 pre-service science teachers at the largest teacher-education institution in Norway, before and after instruction of an astronomy module, and (ii) 922 high-school students at different schools in Oslo, the Norwegian capital, 557 of them age 12-13 (before instruction of a physics/astronomy module), and 435 of them age 14-15 (post instruction). We present results of a ranking task that probed these students' understanding of sizes and distances in the universe. Unexpected findings include that significant fractions of high school students – both before and after instruction – thought that the radius of the Earth is smaller than the height of the Earth's atmosphere (>55%), that the Pole star is contained within the Solar System (>60%), and that planets are larger than stars (>40%). The pre-service teachers fared better pre-instruction, and also showed more significant gains post-instruction.

FK04: 9-9:10 a.m. Transition Between Different Astronomical Frames of Reference

Contributed – David Pundak, Kinneret College, Kibbutz Ashdot Yaacov Ichud, Joran Valley, Israel 15155; dpundak@gmail.com

Students' approaches toward astronomy can be divided into four conceptual frames of references: Mythical – pre-scientific, Geocentric, Heliocentric, Sidereal – scientific. Each frame offers a different interpretation for astronomical phenomena. A frames of reference survey from 1990 was adapted and improved for the research, allowing students to choose their answers according to their preferred frame of reference. This tool was administered pre- and post- an elective astronomy course, studied in an engineering school. Results indicate transition toward a more scientific approach among the students. Consistency of the transition remains to be examined.

FK05: 9:10-9:20 a.m. Teaching the Skills of Professional Astronomy Through Collaborative Introductory Labs

Contributed – Derek C. Richardson, University of Maryland, Department of Astronomy, College Park, MD 20742-2421; dcr@astro.umd.edu*

Fatima Abdurrahman, Alice Olmstead, Sarah Scott, Melissa N. Hayes-Gehrke, University of Maryland

The University of Maryland courses ASTR120 and ASTR121 (with lab) form a two-semester introduction to astrophysics required for the Astronomy major. Here we report on successes and challenges of transforming the lab, where the goal is to explore astronomical content through practical exercises that require students to develop skills needed for professional astronomy. This is achieved in part by: focusing on a limited number of fundamental topics in the lab; requiring students to actively think about their analytical approach; motivating the topics by having students respond to readings from Astrobites.com beforehand; and providing students with a template to guide them in writing reports, where the template becomes more sparse for later labs. Students collaborate during lab, and regularly critique and offer suggestions on each other's writing. This effort is supported in part by a grant from the University of Maryland TLTC Elevate Fellows program.

*Sponsored by Alice Olmstead.

FK06: 9:20-9:30 a.m. Improved Conceptual Understanding in Active Learning Reformed Introductory Astronomy Courses

Contributed – Carol L. O'Donnell, George Washington University, Corcoran, 725 21st St., NW, Room 105, Washington, DC 20052-0002; codonnel@gwu.edu*

Peter Hahn, Oleg Kargaltsev, Bethany Cobb, Raluca Teodorescu. George Washington University

The Department of Physics at George Washington University (GWU) has reformed its undergraduate introductory astronomy courses for non-science majors using the model referred to as SCALE-UP (Student-Centered Active Learning Environment with Upside-down Pedagogies), where lecture and lab are integrated and students work collaboratively to complete hands-on, computer-rich, interactive classroom activities. In this session, we will discuss the history of course development, current course design, and student outcomes relative to traditional Astronomy courses. We will demonstrate that SCALE-UP has had a positive impact on students' understanding of Astronomy concepts by sharing comparisons of normalized gains on standardized assessments relative to national averages for interactive and traditional astronomy courses, as well as comparisons between class averages on common exams in both lecture and SCALE UP classes.

*Sponsored by Dr. Oleg Kargaltsev

Session FL: Innovative Engagement Strategies for Lecture Classes

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Physics in Two-Year Colleges
Date: Wednesday, July 29
Time: 10–10:20 a.m.

Presider: Sherry Savrda

FL01: 10-10:10 a.m. ILDs to Engage Students in Large (or Small) Lectures – Including Clickers and Video Analysis

Contributed – David R. Sokoloff, Department of Physics, University of Oregon,Eugene, OR 97403-1274; sokoloff@uoregon.edu

Ronald K. Thornton, Tufts University

Interactive Lecture demonstrations (ILDs) using an eight-step process to engage students in the learning process[1] have been demonstrated to enhance learning of introductory physics concepts.[2] This talk will illustrate the research-validated ILD strategy, and present examples including more recently developed ILDs using clickers and video analysis.

1. David R. Sokoloff and Ronald K. Thornton, *Interactive Lecture Demonstrations* (Wiley, Hoboken, NJ, 2004).
2. David R. Sokoloff and Ronald K. Thornton, "Using Interactive Lecture Demonstrations to create an active learning environment," *Phys. Teach.* **35**, 340 (1997).

FL02: 10:10-10:20 a.m. Tips for Making Your Lectures Highly Interactive

Contributed – Michael J. Ponnambalam, Sundaranar University, 7-40 Sannathi St., Vadakkankulam, Tirunelveli District Tamil Nadu, TN 627116 INDIA; michael.ponnambalam@gmail.com

Many universities do not have the modern studio arrangement for their classes. And some do not even have the facility for using "clickers." Interestingly, even in such situations, one can make the classes interactive. As the proverb goes, "Where there is a will, there is a way." The author will share his experience in several Third World countries on how he makes his classes highly interactive—even when there is no electricity!

AAPT
PHYSICS EDUCATION

Awards Session: Robert A. Millikan Medal, 2015 – *Robert A. Morse*

Location: SSU - Hoff Theater
Date: Wednesday, July 29
Time: 10:30-11:30 a.m.

Presider: Steven Iona

Robert A. Morse
St. Albans School
Washington, DC

Facets of Physics Teaching – Pedagogical Engineering in the High School Classroom

Robert A. Morse, St. Albans School, 3001 Mount Saint Alban, Washington, DC 20016; ramorse@rcn.com

Historically, the practice of engineering developed as a cut-and-try discipline separately from science. As knowledge accumulated, the two disciplines began to inform each other. Early in my career, much the same was true of the relation between the art and craft of teaching and the science of learning. In the half century since, significant useful knowledge about learning physics has been developed by the growing physics education research community, particularly regarding introductory physics. Simultaneously, the development of powerful computer technology has made a variety of relatively expensive powerful equipment available to schools. Teachers must decide how to select and use newly available resources effectively, a process that might be called curriculum design but that I prefer to think of as pedagogical engineering. I will discuss and give examples of this process and touch as well on various other aspects of improving physics teaching in high schools.

Session TOP08: Physics On the Road: An Introduction

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Science Education for the Public
Date: Wednesday, July 29
Time: 11:30 a.m.–1 p.m.

Presider: Steve Shropshire

Join demonstration and outreach experts in a panel discussion on ongoing efforts to develop a "How-To" guide for physics on the road outreach.

Session TOP09: PERTG Town Hall

Location: SSU - Benjamin Banneker B
Sponsor: AAPT PERTG
Date: Wednesday, July 29
Time: 11:30 a.m.–1 p.m.

Presider: Stephen Kanim

Town Hall meeting of the Physics Education Research Topical Group

Session TOP10: iOS and Android App Show

Location: SSU - Juan Ramon Jimenez
Sponsor: Committee on Educational Technologies
Date: Wednesday, July 29
Time: 11:30 a.m.–1 p.m.

Presider: Lee Trampleasure

Do you have a favorite app for your physics classroom? Do you want to see others' favorite apps? Come to this discussion.

Session TOP11: Proposed AAPT Governance Changes II

Location: SSU - Charles Carroll B
Sponsor: AAPT
Date: Wednesday, July 29
Time: 11:30 a.m.–1 p.m.

Presiders: Mary Mogge, Beth Cunningham

Although AAPT's executive office is currently located in College Park, MD, the Association has been incorporated in the state of New York since 1957. Recently, the New York state legislature passed the Nonprofit Revitalization Act of 2013 and the new act became effective on July 1, 2014. Much of AAPT's governance is in compliance with the new act. However, there are some important changes that AAPT needs to make in order to be compliant with the new act. A number of changes have already been made such as adopting new Whistleblower and Conflict of Interest policies. The final step is to modernize AAPT's Constitution and By-Laws and recast these into By-Laws. This session will describe changes to the By-Laws and outline the vote that will take place this fall during the general election.

Session GA: Best Practices for Video Use and Online Education

Location: SSU - Benjamin Banneker A
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Physics in Two-Year Colleges
Date: Wednesday, July 29
Time: 1:30–3 p.m.

Presider: Dianne Phillips

GA01: 1:30-1:40 p.m. An Online Physical Science Course: Success Predictors and Pitfalls

Contributed – Robert D. Collins, University of Alabama in Birmingham, 704 Bailey Brook Circle, Birmingham, AL 35244; robertcollins1776@hotmail.com

James C. Martin, Lauren Rast, David L. Shealy, University of Alabama in Birmingham

We have designed, created and implemented an online physical science course based on the scientific method, hands-on experiences with integrated laboratory, discussions, group projects, and exams. The course uses a locally developed online textbook that employs frequent student skills assessments and provides immediate feedback. The text and labs use familiar contexts – cars and driving – to illustrate and teach new physics concepts. Key success factors included using project management processes, having a multi-disciplinary team with essential skills, automating a relatively simple course, allocating sufficient calendar time and staff hours, using a robust computerized learning management platform, and providing enough staff to supply the personal attention desired by students and to rapidly adapt the course in response to problems. We will also discuss successes and issues that were encountered during our first two semesters, such as unrealistic student expectations and course materials which required improvement to be effective in an online environment.

GA02: 1:40-1:50 p.m. Forming Connections: Personalized Approach to Online Learning at Susquehanna University

Contributed – Samya Zain, Department of Physics, Susquehanna University, 514 University Ave., Selinsgrove, PA 17870; zain@susqu.edu

Stephanie Schneider, Robert Everly, Department of Physics, Susquehanna University

Marie Wagner, Office of Information Systems, Susquehanna University

In a small liberal arts college, like Susquehanna University, students enroll in online classes with diverse backgrounds, from novices to experts. We recognize that in many online courses students feel unengaged and are often left reading from a book. As a result students struggle with the material and especially with problem-solving which is an integral part of the introductory physics course. The strategy we have employed is to keep the course very organized, be as interactive as possible from delivery of lectures to participation in lab. Videos were created to help the students feel more connected to the material which allows students to experience a more typical classroom setting verses impersonal simulations. Lecture videos were kept confined to a single topic and about ten minutes in length. These strategies have delivered encouraging results as well as help define a pathway to make stronger teacher-student connections for future online physics classes.

GA03: 1:50-2 p.m. Discovering Mechanics Problems with Dependent Responses in a MOOC

Contributed – Trevor A. Balint, George Washington University, 725 21st St., Washington, DC 20052; tabalint@gwu.edu

Raluca Teodorescu, George Washington University

Kimberly Colvin, University of Albany-SUNY

Youn-Jeng Choi, David Pritchard, Massachusetts Institute of Technology

We searched for pairs of problems that students answer similarly in the MIT's MOOC 8.MReVx. We plan to use such pairs, or groups of pairs, to identify skills that students actually use to solve problems. To avoid false dependencies that arise when skillful (unskillful) students answer both problems correctly (incorrectly), we divided the students into ability-based groups using three sorting methods: skill from Item Response Theory, success rate on attempted problems, and success rate on all problems. The results show similar trends for all three methods, with each method yielding consistent numbers of dependent problem pairs well above chance. We will discuss our findings, implications for instruction, as well as our plans to cluster the pairs of problems and identify the types of skills associated with each cluster.

GA04: 2-2:10 p.m. Making Good Physics Videos (for Flip the Classroom and Beyond)

Contributed – James J. Lincoln, PhysicsVideos.net, 5 Federation Way, Irvine, CA 92603; LincolnPhysics@gmail.com

Flipping the Classroom and the emergence of free online video hosting has led many of us to be asked to make videos of our lessons and demos. In this talk, you will learn the five methods of video engagement, and effective video writing techniques that will improve your video quality and improve audience engagement. Tips and ideas for effective and engaging physics demos are also included.

GA05: 2:10-2:20 p.m. Video Supplements in Physics Courses at Colorado School of Mines

Contributed – Todd Ruskell, Colorado School of Mines, 1523 Illinois St., Physics Department, Golden, CO 80401; truskell@mines.edu

Mark Lusk, Alex Flournoy, Patrick Kohl, Eric Toberer, Colorado School of Mines

At Colorado School of Mines we have developed online video materials for several courses in our physics curriculum. In our Physics I course, we created video lectures for each topic to model problem solving. In our majors courses of Intermediate Mechanics and Advanced Electricity and Magnetism, pre-course videos are an essential component of the flipped classroom model. In mechanics, most these videos take the form of "pre-written" lecture notes, revealed and narrated in chunks. In E&M, the notes are written and narrated synchronously, with written notes often accelerated from their real-time pace. Video lectures in our senior-level elective Solid State Physics course take the form of scripted student-faculty dialogues, also in support of a flipped classroom. We discuss the differences in pedagogy for the videos in each course, the production tools used, the workflow for producing our videos, and the time commitment required by those looking to develop similar resources.

GA06: 2:20-2:30 p.m. Can Direct Measurement Videos Inspire Lab-like Learning?*

Contributed – Matthew Ted Vonk, University of Wisconsin River Falls, 410 South Third St., River Falls, WI 54022; matthew.vonk@uwrf.edu

Labs can offer students an opportunity to confront physics first-hand and to gain experience using science practices. As such, hands-on labs are an important learning tool that has played a foundational role in science education since the time of Galileo. But labs also have features that make them difficult to implement in practice. They are often time consuming to plan, setup, and perform, expensive to implement, and fraught with potential missteps that can send confused students into a spiral of misunderstanding. Our Direct Measurement Video team is working to create several series of videos with an interface that allows students to interact with them in a lab-like way, but with less of the cognitive overload that tends to undermine physical labs. In this talk, I will present our vision of the pedagogical possibilities of video and highlight our progress toward the goal.

*This work is supported by NSF TUES #1245268

GA07: 2:30-2:40 p.m. Impact of Interactive Video on Student Understanding of Centripetal Motion*

Contributed – Kathleen M. Koenig, University of Cincinnati, 3758 Hubble Rd., Cincinnati, OH 45247; kathy.koenig@uc.edu

Robert Teese, Rochester Institute of Technology

Priscilla Laws, David Jackson, Dickinson College

Patrick Cooney, Millersville University

One of the short interactive video vignettes (IVVs) developed by the LivePhoto Physics Group targets student understanding of centripetal motion. This eight-minute web-delivered vignette was designed to support outside-of-class activities such as textbook readings. The vignette includes real-world and laboratory-based video segments and users must answer multiple-choice questions throughout. Student responses are echoed back to them while they see the questions resolved. As part of an evaluation to determine the impact of the IVV on student understanding of centripetal motion, a study was conducted that compared two groups of students: those completing the IVV as a homework assignment in a college-level introductory course to those who did not complete it. Both groups of students were pre- and post-tested using the Force Concept Inventory. Results will be presented to demonstrate the impact of the IVV on student learning of targeted concepts.

*Supported by NSF TUES (DUE 1123118 & 1122828).

GA08: 2:40-2:50 p.m. A Set of Interactive Video Vignettes on Electrostatics*

Contributed – Patrick J. Cooney, Millersville University, 461 State St., Lancaster, PA 17603; pjcooney@hotmail.com

Robert A. Morse, St. Albans School

Robert B. Teese, Rochester Institute of Technology

Maxine Willis, Dickinson College

The LivePhoto Physics Group has under development three new short Interactive Video Vignettes about basic electrostatics. They feature Bob Morse in active dialog with three introductory-level physics students and make use of hands-on activities from his well-known AAPT workshops.[1] Interactive Video Vignettes[2] are online presentations that employ active-learning strategies developed through Physics Education Research. They typically focus on a single topic, are short (5-10 minutes), and use multiple-choice questions, branching and video analysis for interactivity. These three vignettes will be evaluated for educational effectiveness during the 2015-2016 academic year and will then be available at ComPADRE(3).

*Supported by NSF grants DUE-1123118 & DUE-1122828.

1. Robert A. Morse, Teaching About Electrostatics (AAPT, College Park, MD, 1992).
2. Priscilla W. Laws, et al., "Using Research-Based Interactive Video Vignettes to Enhance Out-of-Class Learning in Introductory Physics," *Phys. Teach.* **53**(2), 114-117 (2015). (3) www.compadre.org/ivv/.

GA09: 2:50-3 p.m. C3PO: Customizable Computer Coaches for Physics Online*

Contributed – Jie Yang, University of Minnesota, 116 Church St. SE, Minneapolis, MN 55455-0213; yang1999@umn.edu

Evan Frodermann, Ken Heller, Leon Hsu, University of Minnesota

Bijaya Aryal, University of Minnesota-Rochester

The University of Minnesota Physics Education Research Group has been developing Customizable Computer Coaches for Physics Online (C3PO), a web-based system designed to provide students with coaching to improve their problem-solving skills. Computers have good potential to provide such coaching because they are patient, non-threatening, and available 24/7 over the Internet. We discuss our recent progress in designing new student and instructor interfaces to make the coaches more easily customized by instructors while at the same time allowing students increased flexibility in choosing their path to a solution.

*This work was partially supported by NSF DUE-0715615 and DUE-1226197.

Session GC: Introductory Courses II

Location: SSU - Margaret Brent A/B
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1:10–2:40 p.m.

Presider: Todd Timberlake

GC02: 1:10-1:20 p.m. Conceptual Language Differences Between Mathematics and Physics

Contributed – Stephen C. Parker, Saint Martin's University, Department of Natural Sciences, 5000 Abbey Way SE, Lacey, WA 98503, sparker@stmartin.edu

Over the past year, I've had the illuminating opportunity to teach some sections of Precalculus II (Trigonometry) in addition to the standard Introductory Physics (calculus and algebra based) courses that I normally teach. As a result of my experiences teaching for the Mathematics Department, I have noticed some subtle differences in the conceptual language that I use in my math classes compared to that of my physics classes. For instance, the term "phase shift" has a slightly different meaning in math compared to when it is encountered in physics. I will point out and discuss the implications of some of these observations, in the hopes that it might help explain some of the puzzled looks you receive when teaching these topics in your own classes.

GC04: 1:20-1:30 p.m. Scratcher (IFAT) Forms for Conceptual Test Questions in Introductory Courses

Contributed – Nicole Ackerman, Agnes Scott College, 141 E. College Ave., Decatur, GA 30030-3797; nackerman@agnesscott.edu

Using conceptual multiple choice questions on tests is advantageous in a class where significant class time is spent on conceptual "clicker questions" and there is limited time available for tests. The Immediate Feedback Assessment Technique (IFAT) answer form was implemented as a way to provide partial credit for correct second choices. Ideally, this method provides better grade differentiation between those who genuinely do not know the material and those who are stuck between two answers or who have misread the question. This was used over thee semesters of a calculus-based physics sequence. Student response was largely positive, but increases in test anxiety were reported, especially when the technique was not introduced at the beginning of the semester.

GC05: 1:30-1:40 p.m. Selected Student Conceptions About Buoyancy

Contributed – DJ Wagner, Grove City College, 100 Campus Dr., Grove City, PA 16127; djwagner@gcc.edu

Randon Hoselton, Shannon Armstrong, Ashley Miller, Grove City College

We have developed a taxonomy of alternate conceptions concerning buoyancy, and we are investigating the prevalence of many of those conceptions in the college student population at Grove City College and other collaborating institutions through the use of conception surveys and interviews. This talk will focus on a few of the most commonly seen alternate conceptions and what, if any, differences we see between different populations.

GC06: 1:40-1:50 p.m. Selected Student Conceptions About Density

Contributed – Ashley Elaine Miller, Grove City College, 200 Campus Dr., Grove City, PA 16127; lindowae1@gcc.edu

DJ Wagner, Grove City College

We have developed a taxonomy of alternate conceptions concerning density, and we are investigating the prevalence of many of those conceptions in the college student population at Grove City College and other collaborating institutions through the use of conception surveys and interviews. This talk will focus on a few of the most commonly seen alternate conceptions and what, if any, differences we see between different populations.

GC07: 1:50-2 p.m. In-Class Optometry: Quick Diagnoses and Quick Fixes

Contributed – David Keeports, Mills College, 5000 MacArthur Blvd., Oakland, CA 94613; dave@mills.edu

Geometric optics provides an alternative to Newtonian mechanics as a starting point for a year of physics instruction. Snell's simple law of refraction explains both image formation by the human eye and the methods used routinely to correct visual defects. In this talk I will discuss a collection of qualitative explanations, quick diagnostic techniques, and temporary methods of vision correction that I present to classes of premedical students. I will focus upon tools that elicit the strongest student response, such as estimation of prescription strength of glasses by merely looking at someone who wears glasses and improvement of vision through temporary reshaping of one's own cornea.

GC08: 2-2:10 p.m. Some Surprising Facts About Spherical Aberration for Thin Lenses

Contributed – A. James Mallmann, Milwaukee School of Engineering, 1025 North Broadway, Milwaukee, WI 53202-3109; mallmann@msoe.edu

Several different types of aberrations limit the quality of images formed by simple lenses. Spherical aberration, one of the simpler aberrations to analyze, is not mentioned in some introductory physics textbooks and is typically discussed only briefly in others. Both a trigonometric method and a method that uses vector forms of the laws of reflection and refraction were used to make specific predictions about spherical aberration for a thin lens. One of the predictions suggests that carefully taken data by a competent student to determine the focal length of a thin lens may be judged to be inaccurate. Other facts about spherical aberration surprised me and may surprise you as well.

GC09: 2:10-2:20 p.m. Four Derivations of Motional EMF

Contributed – Carl E. Mungan, U.S. Naval Academy, Physics, Mailstop 9c, Annapolis, MD 21401-3217; mungan@usna.edu

The introductory-level formula for motional EMF can be obtained a number of different ways. It is instructive to lead students through the different derivations in the following specific sequence, because each method brings out a different important aspect of the situation. The first three ways can be used with majors and non-majors alike. The last approach is optionally for physics majors who have been exposed to the idea that a magnetic field is an electric field viewed in a moving reference frame. (1) Apply Faraday's law to a conducting bar sliding on a U-shaped wire. (2) Use work to calculate the change in electrostatic PE of mobile charges driven along a conducting bar moving in a magnetic field. (3) Consider the balance between the applied and magnetic-braking powers as a conducting bar slides on a U-shaped wire at constant velocity. As a bonus, verify Lenz's law. (4) Compute the emf as the integral of the electric field in the bar's frame which is the transform of the magnetic field in the lab frame.

GC10: 2:20-2:30 p.m. Addressing Student Difficulties with Electrostatics Concepts in Conductors

Contributed – Ryan L. C. Hazelton, University of Washington, Seattle, WA 98195; ryanhaz@uw.edu

Peter S. Shaffer, Paula R. Heron, University of Washington

We have been conducting a long-term investigation at the University of Washington into student difficulties with electrostatics concepts. One of the results from this study suggests that standard lecture instruction does not provide students with a coherent conceptual model to understand conductors in electrostatics. To address these difficulties, we developed a new tutorial worksheet for Tutorials in Introductory Physics on the electric properties of conductors. In this talk I will use examples of pre- and post-test data to demonstrate an effective strategy to help students understand this topic.

GC11: 2:30-2:40 p.m. Extreme Floodwaters: An Interdisciplinary Approach to Drag Forces

Contributed – Kenneth A. Pestka II, Longwood University, 201 High St., Farmville, VA 23909; pestkaka@longwood.edu

In 1982 the Lawn Lake Dam in Rocky Mountain National Park burst producing extreme floodwaters with water-walls that were estimated to be over 25 ft. tall, moving boulders weighing over 400 tons. Several activities will be presented at a level appropriate for AP or introductory university physics courses that will enable students to estimate the water flow needed to move such enormous rocks. The activities presented have a natural appeal and have applications to environmental science, civil and environmental engineering and encourage students to become environmental detectives.

Session GD: PER: Diverse Investigations III

Location: SSU - Benjamin Banneker B
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1:30–2:40 p.m.

Presider: Ben Van Dusen

GD01: 1:30-1:40 p.m. A Seventeenth-Century Analogue to Contemporary Physics Education Reform

Contributed – James Reardon, University of Wisconsin-Madison, 1150 University Ave., Madison, WI 53706; jcreardon@wisc.edu

Already in 1630 we find an author noting that learners are liable to respond "by rote, as parrots." If we would avoid this in our teaching, we should imitate the method of questioning used by Socrates: "Some dialogues in Plato were worth the reading, where the singular dexterity of Socrates in this kind may be observed and imitated." The author is George Herbert, the work is "A Priest to the Temple: the Country Parson, His Character, and rule of Holy Life", and the activity at hand is catechizing the faithful. I am fascinated that Herbert addresses an issue still important to contemporary reformers of Physics education, using the same words. In this brief talk I try to establish analogues between ecclesiastical educational practices in 1630 England and contemporary USA, and translate Herbert's advice for reform into terms suitable for the training of physics teachers.

GD02: 1:40-1:50 p.m. Andragogy or Pedagogy When Modeling Learning Experiences for Adult Learners?

Contributed – C. Dianne Phillips, NorthWest Arkansas Community College, One College Dr., Bentonville, AR 72712; dphillips@nwacc.edu

Andragogy is the "art and science" of teaching adults. Is it necessary to distinguish between Pedagogy and Andragogy when modeling learning experiences specifically for the adult learner? The EMPACTS (Educationally Managed Projects Advancing Curriculum, Technology and Service) project-based learning model was developed specifically for the unique needs of the adult learner. Courses that employ the EMPACTS delivery system, use the EMPACTS project to enhance the learning of course content as adult learners transition from a socialized "passive" learning experience to one of "active," self-directed ownership in the process. Pedagogical frameworks are historically designed for K-12 learners who need structure, direction and greater facilitation in the learning process. Adult learners learn best if they are allowed to use their own knowledge and life experiences as they apply specific course content to real world problems. The EMPACTS model encourages collaboration and the use of technology as adult learners design and complete semester long projects.

GD03: 1:50-2 p.m. Characteristics of Well-Propagated Instructional Strategies and Materials Across STEM Disciplines*

Contributed – Raina M. Khatri, Western Michigan University, 817 Vine Place, Kalamazoo, MI 49008; raina.m.khatri@gmail.com

Charles Henderson, Western Michigan University

Renee Cole, Courtney Stanford, University of Iowa

Jeff Froyd, Texas A&M University

While the STEM education community has developed many new pedagogies and materials, not many have been successful in reaching a wide audience. This study is part of a larger effort to understand how new pedagogies and materials can become widely used, by learning more about those that have become well-propagated. Experts across STEM disciplines were asked to identify well-propagated instructional strategies and materials in their disciplines. We created a categorization scheme for the strategies and materials and gathered evidence to evaluate the extent to which the innovations they suggested had propagated. This presentation will discuss the general characteristics of well-propagated instructional strategies and materials. Most have been funded by multiple grants over time and emphasize changes in approaches to instruction, not changes to content. Further, their propagation strategies were adapted to the resources and degree of collaboration with colleagues required by the instructional strategy.

Supported, in part, by NSF#1122446.

GD04: 2-2:10 p.m. From Idea to Implementation: Initiating Studio-style Reforms in Academic Departments

Contributed – Alexis V. Knaub, Western Michigan University, 1903 West Michigan Ave., Kalamazoo, MI 49008; avknaub@gmail.com

Charles Henderson, Western Michigan University

Robert Beichner, Kathleen Foote, North Carolina State University

Melissa Dancy, University of Colorado-Boulder

Successful pedagogical change in an institution is often built on a foundation of prior efforts and can have a non-linear trajectory. North Carolina State University's Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP) is a studio-style instructional approach that modifies the classroom structure and pedagogy to promote interaction. There can be challenges when adopting this radical reform, which reconceptualizes the role of teacher and student in a novel learning environment. Using case studies of SCALE-UP secondary implementers, we explore the beginnings of SCALE-UP within departments in a variety of institutions and STEM disciplines. We examine the context of these departments and institutions prior to SCALE-UP, the key players who drive the change, and the events and strategies that lead to implementation. This talk notes commonalities and differences that occurred in successful SCALE-UP implementations. Does successful educational change follow a strategic plan or does serendipity play a significant role?

GD05: 2:10-2:20 p.m. Updating Physics Labs for First-Year Medical Students

Contributed – Stephen W. Peterson, University of Cape Town, Department of Physics, Rondebosch, Western Cape 7701, South Africa; steve.peterson@uct.ac.za

Saalih Allie, Jeff Fearon, University of Cape Town

The medical degree at the University of Cape Town is a six-year undergraduate degree, including a one semester physics course (PHY1025) during the first year. In previous years students have often expressed negative sentiments toward the laboratory component of the course – in which a fairly rigorous approach to measurement had been adopted – viewing it as disconnected from the theory or simply as irrelevant to their medical training. This has led to revising the laboratory curriculum, focusing on two goals (1) improving the connection between lab and lectures and (2) highlighting skills that are relevant for a future as a medical doctor. As part of the evaluation of the new labs (being piloted for the first time) we are using E-CLASS to measure student attitude at the start (February) and the end of the course (May). We briefly describe the new laboratory curriculum and then present our results.

GD06: 2:20-2:30 p.m. Negotiating Positionings within Small Groups in Introductory Physics

Contributed – May H. Lee, 620 Farm Lane, 301E Erickson Hall, East Lansing, MI 48824; leemay1@msu.edu

Vashti Sawtelle, David Stroupe, Marcos D. Caballero, Alicia Alonzo, Michigan State University

To provide opportunities for students to engage meaningfully with core disciplinary concepts and practices in physics, an introductory calculus-based mechanics course was designed so that students collaborated in small groups to solve complex story problems. Our research focuses on how collaboration between group members affects their opportunities to learn and do physics. Qualitative methods were used to analyze video-recorded small group discussions over a three-week period. The dynamics of the social interactions between group members were analyzed through positioning theory (Davies & Harré, 1990). Preliminary findings indicate that group members seemed to position themselves as capable of doing physics. Additionally, each group member was positioned by his or her peers and/or instructor as either more or less knowledgeable in doing physics. As a work in progress, we report on how students negotiate these positionings from multiple sources.

GD07: 2:30-2:40 p.m. Further Investigations into the Effectiveness of Collaborative Group Exams

Contributed – Joss Ives, University of British Columbia, 6224 Agricultural Rd., Vancouver, BC V6T 1Z4 Canada; joss@phas.ubc.ca

I will report on two years of results of a study designed to measure the effectiveness of an instructional strategy known as two-stage exams or collaborative group exams. This exam format first has the students take the exam individually. Once all the students have handed in their individual exams, they organize into collaborative groups of three or four and take the same exam again with only a single copy of the exam being given to each group. Different versions of the group exam feature different subsets of the questions from the individual exam. Questions isomorphic to the exam questions were administered on the end-of-course diagnostic and comparisons, using the relevant isomorphic question, are made between the students that saw a given question on the group exam and those that did not.

Session GE: Professional Skills for Graduate Students (Panel)

Location: SSU - Juan Ramon Jimenez
Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Research in Physics Education
Date: Wednesday, July 29
Time: 1:30–3 p.m.

Presider: Abigail Daane

GE01: 1:30-3 p.m. Selection, Generalization, and Theories of Cause in Case-Oriented Physics Education Research*

Panel – Amy D. Robertson, Seattle Pacific University, 3307 Third Ave W, Suite 307, Seattle, WA 98119-1997; robertsona2@spu.edu

Sarah B. McKagan, American Association of Physics Teachers

Rachel E. Scherr, Seattle Pacific University

Case-oriented physics education research – which seeks to refine and develop theory by linking that theory to cases – incorporates distinct practices for selecting data for analysis, generalizing results, and making causal claims. Unanswered questions about these practices may constrain researchers more familiar with the recurrence-oriented research paradigm – which seeks to inform instructional predictions by discerning reproducible, representative patterns and relationships – from participating in or critically engaging with case-oriented research. We use results from interviews with physics education researchers, a synthesis of the literature on research methodologies, and published examples of case-oriented and recurrence-oriented research to answer "hard-hitting questions" that researchers may pose. In doing so, we aim to substantiate our position that both case-oriented and recurrence-oriented PER are rigorous but that the rigor is of a different nature in each paradigm.

*This material is based upon work supported by the National Science Foundation under Grant Nos. 0822342 and 122732.

GE02: 1:30-3 p.m. Affordances and Limitations of Quantitative and Qualitative Methods

Panel – Andrew Elby, University of Maryland, College Park, Department of TLPL, College Park, MD 20742-1115; elby@umd.edu

In this workshop-style session, Steven Pollock and I will involve participants in qualitative and quantitative analysis of some data as a springboard to meta-level discussions about the affordances and limitations of the methods and how they can work together, at the level of an individual study or at the level of PER more broadly, to provide deeper understandings of physics learning. I will engage participants in analysis of a brief segment of classroom video, and Steven will share and discuss analyses of some quantitative datasets. Then we will facilitate discussion of how the respective roles that quantitative and qualitative analyses can play in researching teaching and learning, and how researchers can decide which methods to employ.

Session GF: Retention and Representation Programs

Location: SSU - Charles Carroll A
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Diversity in Physics
Date: Wednesday, July 29
Time: 1–3 p.m.

Presider: Dimitri Dounas-Frazer

GF01: 1-1:30 p.m. Supporting Community Development and Identity Construction for Underrepresented Physics Undergraduates

Invited – Tammie Visintainer, Tolman Hall, Berkeley, CA 94720-7300; tvis@berkeley.edu

This research examines how participation in a diversity-focused physics program impacts processes of disciplinary learning and identity construction for incoming undergraduate students who are underrepresented in the physical sciences. This study utilizes interviews with participants, program observations, and pre/post program surveys to document the types of program resources that help students develop a sense of community and belonging. Findings show that aspects of students' identities (e.g. perceived ability, gender) and ways of knowing shape how they see themselves in relation to the program community. In addition, how students experienced program elements such as explanation building and collaborative problem solving depended on if they felt the community valued their ideas. Findings underscore the need to better understand the experiences of incoming undergraduates who are underrepresented in the physical sciences in order to provide program resources that support intersections of students' identities and ways of knowing in physics learning environments.

GF02: 1:30-2 p.m. CU-Prime: Promoting Equal Access to Participation in Physics at CU-Boulder

Invited – Robert D. Niederriter, University of Colorado, Boulder, 390 UCB, Department of Physics, Boulder, CO 80305; robert.d.niederriter@gmail.com

Jasmine Brewer, University of Colorado, Boulder

Founded in 2013, CU-Prime is a student-led initiative focused on increasing diversity and improving retention rates among undergraduate physics students at the University of Colorado Boulder. We have implemented three programs to reduce the barriers, such as lack of information and lack of access to mentors and role models, that hinder students from underrepresented groups pursuing careers in physics. We teach a new course for first-year students emphasizing self-directed inquiry and other skills for success in physics; we connect undergraduates with graduate student mentors who provide advice and encouragement; we host an undergraduate-focused seminar series engaging students with current physics research, providing role models from a variety of backgrounds, and encouraging undergraduate research. We report on the design, implementation, and achievements of these CU-Prime activities and discuss implications for increasing diversity and retention of undergraduate physics students at CU-Boulder. http://www.colorado.edu/studentgroups/cuprime/

GF03: 2-2:30 p.m. Multiple Perspectives on Building a Student-centered Physics Bridge Program: Sundial at Arizona State University

Invited – Anna M. Zaniewski, Arizona State University, PSF 470, Tempe, AZ 85282; azaniews@asu.edu

Alexandra Stich, Brianna Thorpe, Arizona State University

Daniel Reinholz, University of Colorado, Boulder

Sundial is an organization at Arizona State University that is a collaborative effort of both students and faculty to create a supportive and diverse community within the physical sciences. Sundial is a similar program to Berkeley's Compass Project; both are members of the Access Network of emerging programs aimed at fostering student success and promoting diversity across the country. ASU's commitment to being an inclusive campus results in a unique population of participants with a broad range of academic preparedness. Our program offerings include a research class, summer bridge program, mentoring, outreach, and social programs. Our analysis shows that mentors create important psychosocial and academic support for students; topics discussed amongst mentoring groups include coursework, stress, and campus opportunities. Students also report feeling supported and listened to as a result of mentoring. In addition, Sundial students viewed the summer bridge program very favorably, and the program helped students form social connections and increase academic confidence. This presentation will include multiple perspectives, including involved faculty and students.

GF04: 2:30-3 p.m. Using Metacognitive Practices to Build a Student Supported Learning Community for Retention of First Generation and Deaf and Hard of Hearing Students

Invited – Corey Ptak, Rochester Institute of Technology, Lomb Memorial Dr., Rochester, NY 14623-5603; cxpsbi@rit.edu

Lack of awareness is a critical metacognitive obstacle to student success. Weak students are least likely to realize their deficiencies, and consistently overestimate their performance. Metacognitive shortcomings are particularly prominent in two at-risk populations: deaf and hard of hearing (DHH) students and first generation (FG) college students. DHH learners significantly overestimate the depth of their understanding and as a result, lag far behind hearing students in STEM areas. Similar metacognitive shortcomings are found in FG students, who often take less rigorous high school courses. This talk describes a program for Integrating Metacognitive Practices and Research to Ensure Student Success (IMPRESS) to address metacognitive weaknesses in order to improve retention of these two target populations. Particular attention will be paid to the challenges in meeting the specific needs of these student populations and developing cross-cultural understanding.

Session GG: Sustaining Thriving Physics Graduate Programs by Embracing Challenges and Opportunities in the 21st Century

Location: Jimenez Hall (JMZ) - 0220
Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Wednesday, July 29
Time: 1–3 p.m.

Presider: Alexandru Maries

GG01: 1-1:30 p.m. Recommended Actions for Sustaining Thriving Programs from the Second Conference on Graduate Education in Physics*

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

We will discuss the challenges and opportunities in sustaining thriving graduate programs in physics based upon discussions of 107 participants at a graduate education in physics conference in 2013. The participants included department chairs and/or directors of graduate studies from 74 physics departments (mostly PhD granting), representatives from industry, national laboratories, and professional societies (including a European representative), and 11 graduate student leaders. Two of the major concerns include the need to adapt to the changing demographics and need to prepare physics graduate students for diverse careers instead of solely focusing on careers in academia. We will discuss recommended actions and best practices to maintain excellent physics graduate programs.

*We thank the National Science Foundation for support.

GG02: 1:30-2 p.m. Changing Physics Graduate Education Demographics: The APS Bridge Program

Invited – Theodore Hodapp, American Physical Society, One Physics Ellipse, College Park, MD 20740; hodapp@aps.org

Brian Beckford, American Physical Society

In nearly every science, math, and engineering field there is a significant falloff in participation by underrepresented minority (URM) students who fail to make the transition between undergraduate and graduate studies. The American Physical Society (APS) has realized that a professional society can erase this gap by acting as a national recruiter of URM physics students and connecting these individuals with graduate programs that are eager to a) attract motivated students to their program, b) increase domestic student participation, and c) improve the diversity of their program. In only two years the APS has placed enough students into graduate programs nationwide to effectively eliminate this achievement gap. The program has low costs, is very popular among graduate programs, and has encouraged a number of universities to adopt practices that improve their graduate admissions and retention. This presentation will describe programmatic elements, and present data that demonstrate the project's effectiveness.

GG03: 2-2:30 p.m. Admissions to Physics Graduate Programs: Challenges to Diversity

Invited – Geoff Potvin, Department of Physics, and STEM Transformation Institute, Florida International University, 11200 SW 8th St., Miami, FL 33199; gpotvin@fiu.edu

It is well known that physics has been slower than several STEM fields in increasing the participation of students from traditionally underrepresented backgrounds. Graduate admissions play a central function in determining who gains access to graduate school and subsequent physics participation. As part of the APS Bridge Program, two national surveys were conducted of departments that award doctorates and Master's degrees as their highest degree to probe the application and admissions processes at these two types of institution. I will present an analysis of how departments incorporate race/ethnicity and gender into their admissions, how GRE scores are used, and the relative importance placed on a number of other student factors. A notable fraction of departments express demand for greater numbers of underrepresented students but simultaneously report a lack of effort towards their recruitment and a dearth of such applicants.

GG04: 2:30-3 p.m. Improving the Content and Pedagogical Content Knowledge of Physics Graduate Students Using Physics Education Research*

Invited – Emily Marshman, University of Pittsburgh, 3941 O'Hara St., Pittsburgh, PA 15260; emm101@pitt.edu

Alexandru Maries, Chandralekha Singh, University of Pittsburgh

Many physics graduate students face the unique challenge of being both students and teachers concurrently. To succeed in these roles, they must develop both physics content knowledge and pedagogical content knowledge (PCK). Our research has involved improving both the content knowledge and PCK of first year graduate students. To improve their content knowledge, we have focused on improving their conceptual understanding of materials covered in upper-level undergraduate courses since our earlier investigations suggest that many graduate students struggle in developing a conceptual understanding of quantum mechanics. Learning tools, such as the Quantum Interactive Learning Tutorials (QuILTs), have been successful, e.g., in helping graduate students improve their understanding of Dirac notation and single photon behavior in the context of a Mach-Zehnder Interferometer. In addition, we have been enhancing our semester long course focusing on the professional development of the teaching assistants (TAs) by including research-based activities. Implications of these interventions for the preparation of graduate students will be discussed.

*We thank the National Science Foundation for support.

Session GH: Teacher, TA, and Faculty Training and Development

Location: SSU - Charles Carroll B
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1:30–2:40 p.m.

Presider: Matthew Perkins

GH01: 1:30-1:40 p.m. What Affects Teachers' Assessments of Their Preparedness to Teach Physics?

Contributed – Susan White, American Institute of Physics, One Physics Ellipse, College Park, MD 20740; swhite@aip.org

John Tyler, American Institute of Physics

Every four years we conduct a Nationwide Survey of High School Physics Teachers. We ask teachers to assess their preparedness to teach physics. Using data from 1997 and 2013, we examine the effects of teachers' academic backgrounds, physics teaching experience, self-identified area of specialization, and sex on their assessment of preparedness. We can examine whether or not men and women with the same characteristics see themselves as equally prepared. Since we have data spanning over 15 years, we can also see whether or not perceptions have changed during that span. We define anyone who teaches at least one physics class to be a physics teacher, so we have teachers from a variety of backgrounds. Thus, we are able to see the impact of various academic backgrounds on one's perception of preparedness. Using ordinal logistic regression, we are able to quantify the relative likelihood of different groups rating themselves equally prepared.

GH02: 1:40-1:50 p.m. The OK PhysTEC Collaborative*

Contributed – Steven J. Maier, NWOSU, 709 Oklahoma Blvd., Alva, OK 73717-2799; sjmaier@nwosu.edu

Jenny Sattler, NWOSU

Karen Williams, ECU

Instead of a single institution shouldering the responsibility of recruiting physics educators, the OK PhysTEC Collaborative is a multi-institutional effort. NWOSU, SWOSU, ECU and OSU are collaborating to recruit future physics teachers into already existing physics teacher preparation programs in Oklahoma. The project began late in 2014 and will be funded until 2017. Sharing the responsibility means sharing resources and ideas, challenges and triumphs and the workload and enthusiasm. In this talk, the current status of the project will be presented along with our ideas for the future.

*Supported by a PhysTEC Recruitment Grant.

GH03: 1:50-2 p.m. The Nature and Origins of Physical Science Teachers' Identities

Contributed – Dale L. Taylor, University of Cape Town, Physics, UCT, Private Bag X3, Rondebosch Cape Town, 7701 South Africa; DL.Taylor@uct.ac.za

Teachers' identities are key because they affect teachers' take-up of innovative pedagogies as well as facilitating their agency in spite of contextual constraints. The question addressed here is: what is the nature of the discourse identities of early career science teachers, and from where are these identities drawn? The sample comprised seven South African physical science teachers who had graduated from a four-year initial teacher education degree, and had three to six years teaching experience. From narrative inquiry interviews, it emerged that their identities were diverse. The teaching degree was core to the identities of three teachers who recognized the shortcomings of their own secondary schooling. In contrast the other teachers' identities drew on their own schooling. All seven teachers drew far more on how rather than what they were taught in the teaching degree; in particular they recruited science pedagogies which were consistent with their identities.

GH04: 2-2:10 p.m. Managing the Classroom Complexity of Personalized Education

Contributed – Michael Dolan, St. Andrew's Episcopal School, 2301 Enfield Rd., Austin, TX 78735; mdolan@socraticbrain.org

Personalizing the learning path and pace for each student can overwhelm even the best teachers' intentions. Doing this in a collaborative inquiry-based physics classroom adds to the challenge. Presented in this session are teaching methods and tools that help manage the complexity and provide more time for differentiated instruction.

GH05: 2:10-2:20 p.m. Design and Implementation of a Physics GTA Development Program

Contributed – Emily Alicea-Muñoz, Georgia Institute of Technology, 837 State St., Atlanta, GA 30327; ealicea@gatech.edu

Carol Subiño Sullivan, Michael F. Schatz, Georgia Institute of Technology

Graduate Teaching Assistants (GTAs) are essential members of the teaching staff for large introductory physics courses, serving thousands of undergraduates every semester. Consequently, it is important for GTAs to receive appropriate preparation before they first enter the classroom. For the past two years, the School of Physics at Georgia Tech has been preparing new GTAs through a training and mentoring program focused on pedagogy, physics content, and career development strategies. Our goal is to produce effective GTAs who can efficiently facilitate student learning, and also to help GTAs acquire and develop transferable skills that they will be able to use in their future career. Here we discuss the elements of our training program, the results seen so far, and the revisions under consideration for its third iteration in fall 2015.

GH06: 2:20-2:30 p.m. Department Action Teams: Empowering Faculty to Make Sustainable Change

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

Daniel L. Reinholz, Melissa H. Dancy, Stanley Deetz, Noah Finkelstein, University of Colorado Boulder

We describe a new type of faculty working group, a Department Action

Team (DAT), that forms one component of a larger strategy towards enacting cultural change in higher education. DATs empower a team of faculty members within a single department to make focused, sustainable change in their department. DATs focus on departmental development, as faculty design and implement strategies to address an educational problem of mutual interest and broad-scale importance (rather than trying to "solve" the problem themselves). This contrasts other faculty development efforts like Faculty Learning Communities (FLCs), which support the individual development of faculty from different departments through reflection on separate education projects. We contextualize the DAT model through a case study of a group within a physics department that is focused on improving gender equity among their undergraduate majors. Building on this case, we offer general principles for facilitating and developing similar groups at other institutions.

GH07: 2:30-2:40 p.m. TOPS: A Report on Our Teaching Experience for Undergraduates Program*

Contributed – Ted Ducas, Wellesley College, 106 Central St., Wellesley, MA 02481-8203; tducas@wellesley.edu

Dan Kleppner, MIT

TOPS (Teaching Opportunities in Physical Science) is a summer program to encourage undergraduate physics majors to pursue pre-college teaching careers. Eight undergraduates from colleges and universities across the nation work with experienced high school teachers to prepare hands-on lessons and then teach them to middle school students in a one-week program, and then high school students in a two-week program. Approximately two-thirds of the participants go on to teaching careers. The experience of actually teaching young learners is a critical aspect of the program's success. TOPS takes place at MIT and is hosted by the MIT/Harvard Center for Center for Ultracold Atoms (CUA). The summer of 2015 is the 13th year of TOPS. We report on its achievements, its lessons and its promise as a model for the development of other Teaching Experience for Undergraduates programs.

*http://cuaweb.mit.edu/Pages/TOPS.aspx

Session GI: Teaching and Learning in Upper Division Physics: Optics

Location: SSU - Prince George's
Sponsor: Committee on Physics in Undergraduate Education
Date: Wednesday, July 29
Time: 1–3 p.m.

Presider: Juan Burciaga

GI01: 1-1:30 p.m. Waves and Optics: a Transition Subject in Undergraduate Physics Curricula

Invited – Jason H. Hafner, Rice University, 6100 Main St., MS 61, Houston, TX 77005; hafner@rice.edu

Optics is ubiquitous in scientific research and technology, yet the subject has no established home in an undergraduate curriculum for physics majors. This talk describes an approach taken at Rice University in which a course on Waves and Optics is taken in the third semester. The course topics can serve as an excellent bridge between the rote nature of first year physics and the longer derivations and deeper insights in upper division physics courses. The specific course topics, their associated demonstrations, and their pedagogical roles will be described. An online version of Rice's Waves and Optics course that is available at edX (http://www.edx.org) will also be described, as well as how it can complement an on-campus course.

GI02: 1:30-2 p.m. Guiding Students to Optical Understanding

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

Optics as an absolutely fascinating subject. All too often optics laboratories devolve into demonstrations of this phenomenon or that phenomenon. This, in turn, drives the joy of discovery from the laboratory and often results in recipe based labs. Lecture can do the same thing and crush student curiosity. Optics lecture can tend towards mathematical "telling" in which the instructor does the math behind various optical processes and students watch the "performance." While the subject material can be covered quickly in this way, what do the students take away? Our goal is to instill in students a sense of independence. This means they must learn to do investigations independently. But they also must learn the mathematical tools of the trade and how to interpret results. I will discuss our present approach to achieve student independence.

GI03: 2-2:30 p.m. Modeling Optics Labs and Advanced Optics Experiments

Invited – Enrique J. Galvez, Colgate University, 13 Oak Dr., Hamilton, NY 13346; egalvez@colgate.edu

The abundance of optical breadboards, optical hardware, and lasers lends to doing modeling labs in the upper-division optics course: simple in objective but fully hands on. Students start with a clean breadboard and build the optical setup the way they designed the experiment. Since the lab uses lasers, the course must start with a discussion of Gaussian beams. Students can then build their own apparatuses, including interferometers and other more elaborate setups. The recent availability of inexpensive spatial light modulators (SLM) presents an opportunity to do computer-generated diffraction experiments with lasers. Experiments that use the SLM can also be used to do more advanced experiments, such as for the study of designer laser modes (e.g., Laguerre-Gauss, Airy), and novel space-variant polarization modes (e.g. vector, Poincare').

GI04: 2:30-3 p.m. Crafting Ray-Tracing Problems with Parabolic Reflectors Beyond the Paraxial Approximation

Poster – Richard A. Zajac, Kansas State University, Salina, 2310 Centennial Rd., Salina, KS 67401-8196; rzajac@ksu.edu

The pedagogical goals of geometrical ray-tracing with curved reflectors can be undermined by students' numerical-only use of the mirror equation, especially in online environments where graphical work seldom gets submitted. We strategically generate ray-tracing problems involving large objects/images with true-parabolic reflectors for which the mirror equation's paraxial approximation fails dramatically, making graphing strategies the least prohibitive means of obtaining a correct answer. The related problem space is mapped and useful areas of convergence are identified. We find that a strategic choice of parameters allows problems to be crafted for which a numerical submission alone is sufficient to verify the student's correct application of graphical-only methods rather than numerical substitution into a formula. Such a purely numerical submission is ideally suited to online homework. The visible failure of the mirror equation in these problems is shown to impact students' appreciation of the paraxial model undergirding the mirror equation.

GI05: 2:30-3 p.m. Implementing Studio Optics in the Undergraduate Physics Curriculum

Poster – Dyan L. Jones, Mercyhurst University, 501 E 38th St., Erie, PA 16505; djones3@mercyhurst.edu

As part of the development of our upper-division physics curriculum, we have created a version of a Studio Optics course. This course is a hands-on course that minimizes "lecture" time and instead focuses on developing students' independent learning skills. This poster will highlight the key aspects of the course, including course design and implementation at a small private institution. It will also provide feedback about students' views on the nature of science and how participating in the Optics course contributes to their affective views about physics and their role as scientists.

Session GJ: Post-Deadline I (Papers)

Location: Jimenez Hall (JMZ) - 0105
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1–3 p.m.

Presider: Anne Cox

GJ01: 1-1:10 p.m. A Comparison of Co-Teaching Models in Large-Scale Introductory Physics Courses

Contributed – Jared Stang, University of British Columbia, 6224 Agricultural Rd., Vancouver, BC V6T 1Z1; jared@phas.ubc.ca,

Co-teaching has been suggested as a method for dissemination of evidence-based teaching strategies and offers potential benefits for both students and faculty.[1,2] We report on two co-teaching arrangements, both involving non-PER (Physics Education Research) mid-career faculty being paired with PER faculty. Data was collected using a variety of methods, including in-class observations of instructor behaviours and student engagement, student surveys and diagnostic tests, and pre- and post-semester interviews with the faculty involved. The two arrangements adopted different co-teaching models. In the first, the instructors took a blocked approach, with a different instructor taking primary control of facilitation in each half of the semester. The second arrangement adopted a more explicitly collaborative approach, with multiple changes of control within each lecture. We will report on the differences and similarities in these two models, including instructor dynamics in the classroom, instructor perspectives, and the resulting student perspectives, engagement, and learning.

1. Henderson et al, *Am. J. Phys.* **77**: 274, 2009
2. Jones and Harris, *College Teaching* **60**: 132–139, 2012

GJ02: 1:10-1:20 p.m. An Educational Kit Based on a Modular Silicon Photomultiplier System

Contributed – Massimo L. Caccia, Universita' dell'Insubria, Department of Science & Technology, Como, NA 22100 ITALY; massimo.caccia@uninsubria.it

Silicon Photomultipliers (SiPM) are state-of-the-art detectors with single photon sensitivity and unique photon number resolving capability. Their application in high-energy physics calorimetry, astrophysics, medical imaging or cultural heritage is currently under study by quite a number of teams. The use of SiPM as an educational tool for graduate and undergraduate students is reported here. The proposed development is based on a modular kit co-developed by CAENs.p.a. and the RAPSODI[1] collaboration, exploiting the project results. The modularity of the system allows planning experiments for undergraduates in physics, addressing a plurality of topics in statistics and basic nuclear science. For every topic, an accompanying suite is being developed, including an instructor's guide, indications on the analysis and a library of routines in MATLAB/SCILAB, a platform widely distributed in the academic community. Exemplary illustrations of the ongoing development are reported, together with an analysis of the student's feedback.

1. RAPSODI is a project approved by the European Commission within the 6th framework program. More info at http://www.rapsodiproject.eu

GJ05: 1:40-1:50 p.m. Increased Student Gain with Reduced Instructor Pain

Contributed – Alan G. Grafe, University of Michigan-Flint, 303 E. Kearsley St., Flint, MI 48502; grafe@umflint.edu

A new instructor who has only been exposed to traditional lecture methods may find the prospect of adopting other, more effective teaching strategies daunting, especially if they are constrained to traditional lecture/laboratory spaces. What may not be so obvious is that an instructor need not perform a wholesale restructuring of their course. Based on personal experiences, this presentation will outline an incremental strategy for adopting more effective strategies while reducing the likelihood that the instructor becomes overwhelmed at any particular step.

GJ07: 2-2:10 p.m. Computational Model of a Weak Spring in Uniform Circular Motion

Contributed – Thomas Dooling, UNC Pembroke, One University Dr., Pembroke, NC 28372-1510; tom.dooling@uncp.edu

Matthew Carnaghi, Aaron Titus, High Point University

Jeff Regester, Greensboro Day School

A computational model of a weak spring spinning in a circle has been written using Easy Java Simulations (EJS). The model calculates the spring extension in its quasi-static state. The model takes into account the spring mass, spring constant, rate of rotation, air resistance, and gravity. The model demonstrates the "Principle of Locality." When the center of the spring is released, the outer end of the spring continues to move on its original circular path. This continues until a wave from the released end makes its way to the outer end. This phenomenon has been seen in real physical systems and was the motivation for making the computer model. The basic math behind the model will be covered and the model itself will be demonstrated under different initial conditions.

GJ08: 2:10-2:20 p.m. Video Analysis, a Whirling Slinky, and the Benefits of AAPT Collaborations

Contributed – Matthew Carnaghi, High Point University, Department of Physics, High Point, NC 27262-3598; carnam12@highpoint.edu

Thomas Dooling, University of North Carolina at Pembroke

Jeffrey Regester, Greensboro Day School

Aaron Titus, High Point University

Video analysis was used to measure the motion of a weak spring released from uniform circular motion, and results were compared to a computational model of the spring. The experiment began as a freshman research project by Matt Carnaghi at High Point University. Matt used an apparatus created by Jeff Regester who presented the apparatus at a NC Section AAPT meeting. Finally, when seeing a poster of experimental results at an NC Section AAPT meeting, Tom Dooling created a computational model of the spring. Besides being scientifically interesting, the project is a great example of the benefits of regional collaborations formed through AAPT. In this talk, videos will be presented and results will be compared to predictions from the computational model. Applications to teaching and the benefits of regional collaborations will be emphasized.

GJ09: 2:20-2:30 p.m. How Educated Is Educated Guess, Anyway? Cueing Effects in Physics Concept Inventories

Contributed – Hani Dulli, Texas Tech University, Physics Department, Lubbock, TX 79409-4349; hani.dulli@ttu.edu

Multiple-choice questions (MCQs) are widely used in higher education. They are particularly useful in large-enrollment classes where they can be used conveniently to engage students and assess their learning. However, due to their very nature, MCQs inadvertently provide cues, which may result in less discriminatory assessment of performance. In my talk, I will present the results of a study in which I investigated cueing effects in two commonly used multiple-choice instruments: the Mechanics Baseline Test (MBT) and the Brief Electricity and Magnetism Assessment (BEMA). I will discuss the method I used and the students' responses as well as the implications of such a study on the interpretation of item response analysis and the development of new instruments.

GJ10: 2:30-2:40 p.m. Optics: A Modeling Approach

Contributed – Taoufik Nadji. Interlochen Arts Academy, 4000 Highway M-137, Interlochen, MI 49643; NADJIT@INTERLOCHEN.org

Most Modeling Workshops around the nation have been focusing on Kinematics and Mechanics topics and a few have been devoted to Optics. The presenter will share his successful foray into the world of Modeling but through the lens of Optics, pun intended! :-)

GJ11: 2:40-2:50 p.m. The Case for the Lorentz Force in Thomson's Jumping Ring

Contributed – Rondo N. Jeffery, Weber State University, Ogden, UT 84408-2508; rnjeffery@msn.com

Farhang Amiri, Weber State University

Experimental results are presented which support the Lorentz force explanation of the ring jump mechanism and not the opposing-poles theory. With AC and DC the ring lifts first on the side of the ring closest to the iron core where the force is greater, because the radial field[1] surrounding the core falls off roughly as 1/r. With a long coil, if the ring is placed below the coil's symmetry line, the force on the ring with AC is down; above the symmetry line the force is up due to the wrap-around of the external field.

1. See iron-filing magnetic-field map in R.N. Jeffery and F. Amiri, *Phys. Teach.* **46**, 350-357 (Sept. 2008).

GJ12: 2:50-3 p.m. Low-cost DIY Sensors and Data Collection for the Physics Lab with Arduino

Contributed – Brian C. Huang, SparkFun Electronics, 6333 Dry Creek Pkwy., Boulder, CO 80305; brian.huang@sparkfun.com

Using the simplicity and power of the Arduino microcontroller and the open-source community, we have developed a series of tools that can be used in experiments, activities, and labs to investigate, measure, and analyze physics phenomena. For many years, data collection devices from PASCO and Vernier have helped classrooms gain a better insight. With the ease of use of the Arduino environment, instructors, lecturers, and lab managers can take this to the next level. In this paper, we will present a series of experiments where students are shown how to build their own data acquisition devices to model and build an understanding around data measurement, uncertainty, and calibration. These works are gaining in popularity among many institutions across the country and are enabling students to design and build their own measurement equipment outside of the traditional lab environments.

Session GK: Post-Deadline II (Papers)

Location: SSU - Pyon Su
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1–3 p.m.

Presider: Don Smith

GK01: 1-1:10 p.m. A Study of Backing Splash of Falling Water

Contributed – Tianyuan Liu, Southeast University, No. 2 Dongnandaxue Rd., Jiangning Development Zone, Nanjing, Jiangsu 211189 PR China; 213143258@seu.edu.cn

This paper focuses on a phenomenon of energy concentration. After a volume of water falls freely into the deep water below, some splashes are caused and gain enough energy to reach the position that is higher than the free-fall height. Through experiment and theoretical analysis, the energy of each step during the process is calculated. Fluid mechanics and wave theory are also used to explain the formation mechanism.

GK02: 1:10-1:20 p.m. Experimental Study on Falling Water Block's Explosion

Contributed – Diwei Li, Southeast University, No. 2 Dongnandaxue Rd., Jiangning Development Zone, Nanjing, Jiangsu 211189 PR China; ldwldc@126.com

It is rarely known by people that a water block of a certain size would explode after falling in the air for some time. In our experiment, the presence of this phenomenon was verified and later we changed different variable quantities, such as its volume, temperature, and the kind of the liquid, to learn more about its process. Finally, we drew quantitative conclusions. Meanwhile, its principle was explained successfully by our intensive analysis, which has something to do with air resistance and liquid surface tension, as well as turbulent flow. It is believed that our study can inspire today's agricultural irrigation system.

GK03: 1:20-1:30 p.m. Mimicking the Heliosphere in the Sink

Contributed – Yijie Xiao, Southeast University, No. 2 Dongnandaxue Rd., Jiangning Development Zone, Nanjing, Jiangsu 211189 PR China; yuetaohannosy@163.com

Muyang Tian, Southeast University

Recently, it was announced by NASA that the 'Voyager 1' satellite had reached the edge of the solar system, which is called 'heliosphere'. It is the first satellite that human beings have used to explore the outer space. Since we know little about the heliosphere, which is the furthest place where the solar wind can reach, we designed an experiment to simulate the solar wind and the heliosphere at home by pouring a stream of water into a sink. The experiment is aimed to investigate the relationship between the velocity and the edge of stream, which could be analogized to the behavior of solar wind. Qualitative and semi-quantitative results have been obtained, which might be a useful reference for further research.

GK04: 1:30-1:40 p.m. On Helmholtz Carousel

Contributed – Yifan Li, Southeast University, No. 2 Dongnandaxue Rd., Jiangning Development Zone,Nanjing, PR China Nanjing, Jiangsu 211189; 15850656599@163.com

The paper is mainly to explore the relationship between Helmholtz carousel rotation speed and bottle shape. We built up the carousels using empty mineral water bottles, and tested the device by changing the frequency of the voice and the shape of the bottleneck. Experiments show that the shape of the bottleneck does have strong influence on the system. Because of the collimator effect, the direction of the air in and out of the bottle is not parallel, the momentum is different as well, resulting in the rotation of the device.

GK05: 1:40-1:50 p.m. On the Wheel Splashing Phenomenon

Contributed – Chengqi Lyu ,Southeast University, No.2 Dongnandaxue Rd., Jiangning Development Zone, Nanjing, Jiangsu 211189 China; lyuchq@gmail.com

Water will be splashed when the high-speed-rotating wheels touch the surface of it. Experimental data indicate that the angle of liquid increases first then decreases with the rotating speed increasing. The model which only considers surface tension fails to explain the phenomenon. As we take the extra force caused by the flow velocity difference into consideration, it matches the result of the experiment accurately.

GK06: 1:50-2 p.m. The Bounce of Ping-Pong Ball Filled with Liquid

Contributed – Heng Fang, Southeast University, No. 2 Dongnandaxue Rd., Jiangning Development Zone, Nanjing, PR China Nanjing, Jiangsu 211189; fh_seu@163.com

We measure the bouncing altitudes of a Ping-Pong ball filled with certain amounts of water. In the experiment, the energy which transforms into the vibration energy of the liquid can be generally observed through the highest altitude. The ratio between vibration energy and total energy can be fit well using our theoretical model.

GK07: 2-2:10 p.m. Physical Model of Work Function Variability with Different Gate Components

Contributed – Bochen Guan, Physics, Yat-Sen School, Sun Yat-sen University No.135, Xingang West Rd., Haizhu,Guangzhou, Guangdong, China 510275; guanboch@mail2.sysu.edu.cn

Xiao Zhang, Physics, School of Physics & Engineering, Sun Yat-sen University

A new model for work function variability (WFV) has been improved, but there is no special research to study the influence of the gate when its composition changes. In this paper we use WFV model to analyze the electrical property of the device when the composition changes. We predict that the threshold voltage variability and the on-state current variability will be more stable when we decrease the proportion the minor composition. Considering it is hard to change the crystal orientation, we find a more convenient way by adding amorphous material and predict its electrical property of the device.

GK08: 2:10–2:20 p.m. Learning About "Impedance" by Video Analysis of a Modified Newton's Cradle

Contributed – Peppino Sapia, University of Calabria, DiBEST UNICAL- Ponte Bucci, cubo 4B Rende 87036, CS 87036 Italy; peppino.sapia@unical.it

Assunta Bonanno, Giacomo Bozzo, University of Calabria

"Impedance" is a very general concept that characterizes a wide and heterogeneous set of physical systems, in connection with the transfer of some physical quantity (ultimately, energy) between interacting subparts of them. Examples of such systems include transmission lines (electric impedance), acoustic and ultrasonic systems (acoustic impedance), and optical systems ("optical impedance", i.e. the refractive index). In order to facilitate the students in the comprehension of the concept of impedance intended as the key factor determining the efficiency of energy transfer between sub-systems, we propose a coherent sequence of laboratorial activities based on the video analysis of a modified Newton's cradle. This mechanical model, based on recurrent collisions among elastic spheres, permits exploring the transfer of momentum/energy between system's subparts, quantitatively exploring the dependence of the transfer efficiency on the ratio of involved masses. We also present the results of a preliminary test of the learning sequence with high school students.

GK09: 2:20-2:30 p.m. Physics on the Hill: The SPS Mather Policy Internship*

Contributed – Ashley Finger, 570 Country Club Dr., Cutchogue, NY 11935; anfinger8@gmail.com

The John and Jane Mather Foundation for Science and the Arts and the American Institute of Physics created the Mather Policy Internship within the Society of Physics Students Summer Internship Program which provides two undergraduate physicists with the opportunity to live in Washington, D.C., and work in the field of policy. It was through this opportunity that I spent last summer working for the Committee on Science, Space, and Technology in the United States House of Representatives. As an intern, I worked on hearings and markups with topics ranging from fusion energy to the future of human spaceflight. My tasks ranged from initial background research and drafting memorandums to photographing events and engaging in social media outreach. This talk will be a summary of my experiences working at the intersection of science and society.

*Sponsored by the Society of Physics Students Summer Internship Program, Sean Bentley

GK10: 2:30-2:40 p.m. Redesigning the Structure and Pedagogy of a Modern Physics Laboratory

Contributed – Charles L. Ramey II, Texas Tech University, Box 41051, Lubbock, TX 79409-4349; charles.ramey@ttu.edu

Beth Thacker, Texas Tech University

The Modern Physics course taught at Texas Tech University (TTU) covers special relativity, many of the previous century's ground-breaking discoveries, and introduces quantum mechanics. It serves as an introduction to the upper-level core physics courses. The course consists of a lecture and a lab, but the lab has not been completely developed. There is equipment for 12 different experimental setups, but a detailed lab manual and an instructor's manual have not been developed. In addition, the existing materials were not developed based on physics education research (PER). I will be addressing the present incohesiveness of the lab and the changes that need to be made in order to enhance the learning experience of the undergraduate students. We have begun by writing pre-labs for each experiment and are working on developing the laboratory materials further, based on PER and with an effort to sync the labs with the students' classroom content knowledge. Redesigning the lab will allow students to experience and test the various accepted theories of the course and learn more about formal laboratory procedures and statistical analysis (recording a detailed laboratory notebook, writing formal reports, and using various pieces of laboratory equipment). Also, many students enter the science field with the expectation that there is no writing involved and are lacking the adequate skills to engage within a professional laboratory; the lab segment of this course is intended to educate students on gathering, critically analyzing and reporting data.

GK11: 2:40-2:50 p.m. Identifying and Analyzing Actions of Effective Group Work

Contributed – Jennifer R. Keil, University of Colorado, Boulder, 2160 Buttercup St., Boulder, CO 80309-0001; jenniferkeil11@gmail.com

Bridget Molloy, Rebecca Stober, Emily Quinty, Valerie Otero, University of Colorado Boulder

Research indicates that cooperative learning leads to an increase in both student achievement and motivation. Yet, instructors often encounter difficulties facilitating group work, especially at the high school level. This study investigates the characteristics of collaborative learning groups participating in the Physics and Everyday Thinking High School (PET-HS) curriculum. Video data of groups engaging in PET-HS activities were collected from eight teachers piloting the curriculum, and salient characteristics of group interactions were identified. These characteristics were organized into a continuum rubric, which provides indicators to suggest the level at which groups are functioning. Reliability and consistency of this tool were assessed. The continuum rubric can then be utilized in the classroom to gauge the current state of group dynamics and inform future interventions to advance student groups along the continuum. Implications for assessing group dynamics, efficacy of interventions, and student achievement will be discussed.

Session GL: Post-Deadline III (Paper)

Location: John S. Toll Physics Building (PHY) - 1204
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1–2:40 p.m.

Presider: Mila Kryjevskaia

GL01: 1-1:10 p.m. Interactive Advanced Laboratory Videos

Contributed – Chad Hoyt, Bethel University, 3900 Bethel Dr. #2336, St. Paul, MN 55112; hoycha@bethel.edu

Benji Copan, Tayt Eiden, Seth Erickson, Peter Heppner, N. Lindquist, A. Slattery, K. Stein, Bethel University

R. Teese, Rochester Institute of Technology.

We describe progress toward interactive, web-based videos that demonstrate advanced undergraduate laboratories. The user can make frame-by-frame measurements of physical phenomena, an experience much like the successful introductory physics videos made in recent years. Here we extend the interactive video to laser cooling and trapping, fluid dynamics, plasmonics and nanotechnology. One activity introduces the user to experiments in a lithium magneto-optical trap: the user measures atomic cloud free expansion after the trap is shut off, leading to a temperature measurement. Another video guides the user through measurements of surface plasmon wavelength, frequency, and related experimental techniques. Another video allows the user to measure dynamics in the Ping Pong cannon for various test conditions through frame-by-frame analysis of high speed video. The videos are designed to enhance student learning, enable free web-based student participation, and to inspire effective participation in undergraduate research.

GL02: 1:10-1:20 p.m. From Start to Finish – Retention of Physics Majors

Contributed – Donna Hammer, Director of Education, Department of Physics, University of Maryland, College Park, MD 20742-4111; dh ammer@umd.edu

Tim Uher, Coordinator, Outreach Inclusion

Lora Price, Physics Graduate Student

The University of Maryland Physics Department's NSF Scholarships in Science Technology, Engineering and Mathematics (S-STEM) project is a unique program that aims to reduce the attrition of students that occurs in the "pre-major-to-major" gap – i.e., students who begin at the university intending to study physics, but do not graduate with a physics degree. To increase the retention of admitted students, the UMD S-STEM program is designed to provide student with financial assistance, a strong sense of community, academic support, and career planning. We will discuss how the program has been integrated into the curriculum and culture of the physics department, and focus on developing key components of the program: a nurturing environment, dedicated mentorship, early research experience, and professional development.

GL03: 1:20-1:30 p.m. Cross-Platform Integration of Mobile Devices for Classroom Instruction and Collaboration

Contributed – Corey Gerving, United States Military Academy, Science Center, Bldg. 753 West Point, NY 10996; corey.gerving@usma.edu

When trying to integrate mobile devices in to an existing infrastructure, several difficulties present themselves. For example, is the new device compatible with the existing operating system, or is the new device compatible with other instructor/student mobile devices? The cross-platform integration of mobile devices poses a growing challenge to their usefulness as instructional and collaborative tools. This talk will address some challenges in the integration of different operating systems on an existing network, and some short-term and long-term options to mitigate the problems. With proper forethought in the integration of these devices, institutions can encourage a broader use of mobile devices (of varying operating systems) for educational and collaborative use.

GL04: 1:30-1:40 p.m. Alexander Graham Bell and Joseph Henry: Telephone Receiver Demonstration in 1875

Contributed – Michael G. Littman, Princeton University, D202a E-Quad, Princeton, NJ 08544; mlittman@princeton.edu

Alexander Graham Bell visited Joseph Henry in 1875. Bell demonstrated a device that was able to produce sound from an "undulating" current. Henry was interested in the device and wanted Bell to publish it. Henry encouraged Bell to get the necessary electrical knowledge to bring his ideas about telephony to the public. I will discuss and demonstrate a re-creation of the effect that the youthful Bell demonstrated to the elderly Henry. Here an empty helix driven by an oscillating current is able to produce a perceptible tone. The phenomenon is known as coil nose and it is an exceptionally simple device that is useful to explain how one can produce sound from electricity.

GL05: 1:40-1:50 p.m. Evaluating Superheroes as an Instructional Model in Elementary Physical Science

Contributed – Joseph M. Carson, Kansas State University, 1026 Osage, Apt. 2, Manhattan, KS 66502; jcarson13.jc@gmail.com

The purpose of this study was to determine effects of implementing superheroes on student reasoning abilities and mental modeling of directional forces. During a learning cycle lesson, 45 fifth graders engaged in designing free-body diagrams using forces and motion of Ironman. Students were introduced to the framework for generating force diagrams, which embedded mathematical reasoning. Through collaborative learning experiences, groups of students presented explanations of superhero movement after observing movie clips. Next, they generated diagrams to present their ideas of motion and amount of force in a given direction. Video analysis revealed four out of six groups successfully generated and explained free-body diagrams. Unexpectedly, intergroup communications fostered conceptual understanding among students struggling with force diagrams. The use of superheroes in elementary physical science does promote deeper level understanding of balanced and unbalanced forces as called for in the Next Generation Science Standards.

GL06: 1:50-2 p.m. Lectures in Large Class, Recitations in Small

Contributed – Chengjin LI, Physics School of Soochow University, Shizi Rd., No.1 Suzhou City, Jiangsu 215006 China; lichengjin@suda.edu.cn

Education is overvalued in the society of China. The whole process of education from baby born to PhD is filled with anticipation from their teachers, parents, even grandparents. With heavy pressure for a long time, students are not interested in study and lack initiative. They faced training, exams, again and again, day after day. They seldom think about what they learn, and why they learn. Physics is more complicated in university than high school. Students can't master it with simple Imitation. Usually, physics is taught in a class size about 50 to 200 students in China. Most lecturers give their lectures directly, with fewer interaction. The teaching model proposed in this paper, that is, giving the lectures in large class, recitations in small, is intended to stimulate the student's initiative. Every student is required to take part in discussion, they are responsible for their grade in accordance with their behavior. In order to make it work, we carry out the procedurization exam.

GL07: 2-2:10 p.m. Student Capstone Research in Thin Film Growth

Contributed – Dennis E. Kuhl, Marietta College, 215 5th St., Marietta, OH 45750; dennis.kuhl@marietta.edu

The difficulty of obtaining clean surfaces makes conducting experimental surface science research with undergraduate students challenging. Research has shown that it is possible to grow thin metal films epitaxially on ordered Si substrates in low vacuum, resulting in clean, ordered surfaces available for study. The results of several student capstone research projects dealing with the growth by thermal evaporation of Cu thin films on etched Si(100) substrates will be presented. Resistivity was measured during growth and analyzed using a Fuchs-Sondheimer scattering model. Theta-2

theta X-ray diffraction was used to examine epitaxy normal to the surface after growth. The critical step in the preparation of the Si(100) is etching in hydrofluoric acid (HF). The etching time and HF concentration were varied to study possible effects on the copper's epitaxy.

GL08: 2:10-2:20 p.m. One Dimensional Sound Wave Resonant Transmission Through an Acoustical Duct

Contributed – Jasmine Knudsen, Metropolitan State University of Denver, 7456 Deframe St., Arvada, CO 80005; jknudse9@msudenver.edu

Studying resonant acoustical wave transmission gives rise to a better understanding of resonant tunneling of matter waves through potential barriers, resonant electromagnetic wave transport in coaxial–cables, and various other types of wave transmission. In this experiment, we focus on a one-dimensional sound wave travelling through a 3" diameter PVC pipe with a series of Helmholtz resonators, attached. The Helmholtz resonators are glass bottles that cause reflections and transmissions based on the frequency of the wave and the size, shape, and most importantly the position of the resonators. We are able to solve the one-dimensional acoustic wave equation with appropriate boundary conditions by modeling the resonators as delta-functions positioned at precise locations along the tube. Using the model we can predict the driving frequencies that would maximize either the transmission or the reflection of the acoustic wave and then experimentally test the model.

GL09: 2:20-2:30 p.m. The Importance of Computational Physics Education: An Undergraduate Perspective

Contributed – Matthew S. Parsons, Undergraduate Physics, Drexel University, 536 Alexander Rd., Princeton, NJ 08540; msp73@drexel.edu

The incorporation of computational physics coursework into the undergraduate curriculum is a challenge, but one that can't be ignored. Throughout my undergraduate career, my own experience with Drexel's curriculum in this area has proven to be invaluable in my development as a physicist. As a case study, I'll give my perspective as a graduating physics student with examples of computational coursework throughout my four years at Drexel.

GL10: 2:30-2:40 p.m. Science Teachers' Conceptual World and Modeling of Color Perception

Contributed – Junehee Yoo, Department of Physics Education, Seoul National University, Kwanak-ro 1, Kwanak-gu Seoul, SE 151-742 Republic of Korea; yoo@snu.ac.kr

Dongwook Lee, Seoul National University

The research aimed to investigate characteristics of conceptual worlds and modeling of novices and experts to get implications for conceptual change. The participants are 30 middle school students and eight science teachers. Participants were asked to construct models that corresponded with a sequence of color perception phenomena including metamerism through small group argumentation activities. Students conceptual world elements and models were more various and intuitive than those of teachers. Results suggest that novices and experts' conceptual change is different. Novices have loosely comprised conceptual world of knowledge rather than theory, their modeling tends to have new models in each context of phenomena if it provides better explanation. Experts have consistent and structured conceptual world of theory, their modeling tends to have coherent model or consistent model based on previous theory even in the new context of phenomena.

Session GM: Post-Deadline IV (Paper)

Location: John S. Toll Physics Building (PHY) - 1201
Sponsor: AAPT
Date: Wednesday, July 29
Time: 1–3 p.m.

Presider: Geraldine Cochran

GM01: 1-1:10 p.m. An International Partnership for Science Outreach*

Contributed – Martin Kamela, Elon University, 2625 CB, Elon, NC 27244; mkamela@elon.edu

The CRHP Science Center is a two-year-old facility housed on the campus of a well-established rural development NGO, in Jamkhed, Maharashtra, India. The Center was established in partnership with Elon University, and is a prototype for a cost-effective support system for STEM secondary education and science popularization in remote areas in India. The Center operates a day-visit program for local school classes, runs science and mathematics teacher workshops, organizes science popularization activities for the community, and provides opportunities for STEM enrichment for older students during the summer break. The partnership offers ongoing opportunities for Elon University students to be involved in science outreach. We present the process of establishing this joint project and outline the initial assessment of the Center's programs. We discuss the challenges and successes in the partnership to date, and the opportunities for the Science Center to maximize its effectiveness moving forward.

*Related website: http://www.jamkhed.org/sciencecenter

GM02: 1:10-1:20 p.m. Characterization of the Relationship Between Identity and Context Dependent Performance in Physics

Contributed – Keron S. Subero, Linfield College, Department of Physics, 900 SE Baker St., Unit A468 McMinnville, OR 97128-6894; ksubero@linfield.edu

Sophia I Cisneros, University of Massachusetts Boston

Research suggests[1] that the context of physics questions found on widely used physics exams has some influence on students' performance, transcending knowledge of physics material or ability to manipulate physics equations. Further studies[1,2] indicate that physics questions worded in a more "everyday" context tend to yield marginally improved performance by female physics students – a traditionally underrepresented demographic in many physics courses. This research aims to broaden the (presently limited) body of research demonstrating reduction of gender-gap through context variation, as well as to tease out students' perceived stereotype threat[3] as a possible overarching factor.

1. "Gender, Context, and Physics Assessment"; Laura McCullough, *J of Int. Women's Studies*; V5(4), 2004.
2. The Role of Context and Gender in Predicting Success in a Modified Laboratory Course Keron Subero; PhD Dissertation, New Mexico State University; 2010.
3. "A threat in the air: How stereotypes shape intellectual identity and performance." Claude Steele, *American psychologist,* 1997

GM03: 1:20-1:30 p.m. Flipping University Physics Classes: Student Responses to Video Packages, Feedback, and Pre-/Post-Tests

Contributed – Roberto Ramos, Indiana Wesleyan University, 4201 South Washington St., Marion, IN 46953; robertoramos99@hotmail.com

A two-semester set of calculus-based introductory university physics courses was taught using a "flipped" class structure in a liberal arts college setting. Outside class, students viewed online video lectures on Classical Mechanics/E&M and Modern Physics prepared either by this author or by a third-party lecture package available over YouTube, while inside the class, students solved and discussed problems and conceptual issues in greater detail. A pre-class online quiz was deployed as a source of feedback. I will report on the student responses to the different video packages using data based on surveys and interviews as well as on learning gains from pre-/post- physics diagnostic tests. The results indicate a broad mixture of responses to different lecture video packages that depend on learning styles and perceptions. Students preferred the online quizzes as a mechanism to reinforce their confidence. The learning gains based on FCI and CSEM surveys were significant. Results will be compared to prior, similar work on an algebra-based physics course by the author.

GM04: 1:30-1:40 p.m. ICT-based Active Learning on Air-Mass in Big Balloons

Contributed – Akizo Kobayashi, Niigata University, 1-2-22 Shindori-nisi Nisiku Niigata, 950-2036 Japan; kobayasi@ed.niigata-u.ac.jp

Akizo Kobayashi, Fumiko Okiharu, Niigata University

We present newly developed ICT-based active learning modules on measurements of air-mass in a big-balloon by using collisions between big balloons or by use of the oscillation of a big-balloon-pendulum. Furthermore we can also measure air-mass in a big balloon by ICT-based investigations of many times "bouncing and free falling" of those on floor, and investigations of oscillating a big balloon attached to a spring. It is noted that these modules are the superior teaching material equal to the historical devices of the Atwood machine which was invented in 1784 by George Atwood as a laboratory experiment to show constant-accelerating-motions. It is also noticed that those are ideal pedagogical ways to make deep conceptual understanding on the basic difference of mass and weight that are difficult to show by only use of general weighting machines.

GM05: 1:40-1:50 p.m. Research on "Static Electric Field" Model-based Teaching

Contributed – Xiao Huang, Zhejiang Normal University, 2958 lowe Ave., Chicago, IL 60616; huangxiao@zjnu.cn

Jie Pei Gao, Zhejiang Normal University

The purpose of this study was to examine the status of Chinese senior middle students' modeling ability, and what aspects of students' modeling ability can be improved after the modeling-based teaching. Therefore, the experimental group and control group were chosen, the pre-test and post-test were conducted before/after the treatment. As to the intervention, modeling-based teaching, which contains "selection and establishment of models - verification and analysis of models - models development " was applied in the "static electric field" topic. The compared t-test analysis between pre-test and post-test of experimental group, independent t-test analysis of post-test between experimental group and control group were conducted. Combined with interviews analysis, key results are obtained and the implications for the treatment of enhancing the modeling ability of senior middle school students in the Chinese science classroom are discussed.

GM06: 1:50-2 p.m. The Educational Impact of Smartphone Implementation in Introductory Mechanics Laboratories

Contributed – Colleen L. Countryman, North Carolina State University, PO Box 8202, Raleigh, NC 27606; cblanz@ncsu.edu

William R. Sams, North Carolina State University

The internal sensors within students' smartphones are capable of collecting the data required of a traditional introductory mechanics laboratory curriculum. Some instructors have already begun to implement these data collection devices into their labs. Our project—titled "MyTech," or "Measurements using everydaY TECHnologies"—includes the development of a curriculum, the creation of a mobile app, and the determination of the impact of students' smartphones on their learning of physics concepts, attitudes regarding their laboratory experience and use of the devices outside of class. We have been able to determine these impacts using a battery of pre- and post-semester testing as well as video recordings throughout the study. Administration of the CLASS, for example, indicates greater positive shifts in "real-world connections" for the section using smartphones. We have also developed a new tool for video analysis that aids in determining the nature of the student-equipment interactions during the labs.

GM07: 2-2:10 p.m. Challenges of Modeling Curriculum Implementation in the High School Classroom

Contributed – Griffin M. Harmon, SUNY Buffalo State College, 1300 Elmwood Ave., Buffalo, NY 14222; gharmon@cbasyracuse.org

As physics instructors regularly address student misconceptions about physics concepts, they must also deal with students' misconceptions about how they learn best. Modeling instruction provides students with a rich physics experience. Students are routinely engaged in group work, hands-on activities, and classroom discussion. For some students, the modeling classroom looks very different than the traditional classrooms they have had success in. There are certain students who initially reject the modeling style of instruction. With guidance and careful planning by the instructor, those students who resist modeling techniques initially can end up having very positive experiences. This talk will share one instructor's experiences and the methods employed to help hesitant students engage in the modeling experience.

GM08: 2:10-2:20 p.m. The Neutron as a Collapsed Hydrogen Atom: X Rays, Nuclear Forces, Nuclear Stability, & Neutron Stars

Contributed – H. Vic Dannon, Gauge Institute, 619 8th St., SE, Minneapolis, MN 55414; vic0user@gmail.com

Robert Y. Levine, Gauge Institute

A neutron may disintegrate into a proton, an electron, and an antineutrino. In Gravitational Collapse, electrons and protons combine into neutrons. We establish that the Neutron is a Collapsed-Hydrogen Atom composed of an electron and a proton: The Electron with Orbit Radius ~9.4 10^-14 m, Speed ~52 Mm/sec, ~327 times faster than in Hydrogen, Angular Velocity ~5.5 10^20 rad/sec, ~184,000 faster than in Hydrogen, Period ~1.1 10^-20 sec, and Frequency ~8.8 10^19 Hz. The ratio between the electron and proton Hydrogen orbits ~42.5 is preserved in the Neutron. The electron's frequency ~10^20 indicates that X rays are due to the excited electron returning from a higher energy Neutron's orbit to a lower Neutron's orbit. The electric force between the electron and the proton is ~3 10^19 the gravitational force. Thus, a Neutron star is created by Electric Collapse. The Neutron's Electric Binding Energy is ~553 times greater than the Hydrogen's. The electric force in the Neutron, ~317,000 times the Hydrogen's, is the source of the Nuclear Force that binds the Nucleus. A Nucleus composed of a proton and a neutron is a Mini One-Electron Molecule H2+, with an electron that orbits the two protons. The Neutrons supply electrons, which Orbitals about the Nucleus bond the protons, and ensure the Nucleus Stability. In Neutron Stars, the Gravitational Forces are negligible compared to the Nuclear Bonding, which keeps the star packed together. Posted to www.gauge-institute.org

GM09: 2:20-2:30 p.m. A Module on Magnetism as a Constructivist Lesson Demonstration for Elementary Education Majors

Contributed – Vazgen Shekoyan, Queensborough Community College, 222-05 56Th Ave., Bayside, NY 11364; vshekoyan@qcc.cuny.edu

Anita Ferdenzi, Queensborough Community College

At Queensborough Community College all elementary education majors are required to take a conceptual physics course. We have developed a learning community linked course between introductory physics and education classes for elementary education majors. Using various instructor-coordinated assignments and in-class activities, students learn how to use a variety of learning strategies as they flex from the role of current student learning physics content material to the perspective of a future teacher studying underlying pedagogical principles for effective physics instruction. As an example of such activities we will present a) a module on magnetism we have developed that served as a demonstration of a constructivist lesson and b) a series of reflective activities that followed the module. A series of physics ISLE-based inquiry activities were created as well for physics learning and further highlighting of constructivist approach of teaching.

GM10: 2:30-2:40 p.m. Investigating Impacts of Teacher Research Experiences

Contributed – John Keller, California Polytechnic State University, San Luis Obispo, CA 93407

Bruce Johnson, University of Arizona

Paul Tuss, Center for Teacher Quality

Numerous programs provide research experiences for pre-service and in-service teachers as a component of teacher preparation and professional development, respectively. These programs provide the opportunity to investigate the impacts of interventions on both teacher-researcher participants and their K-12 students. We will describe the Collaborative Around Research Experiences for Teachers (CARET) supported by the APLU Science and Mathematics Teaching Imperative and 100Kin10 to link teacher researcher programs across the nation to develop shared measures to characterize some of these impacts (URL). We will also present the development of a longitudinal tracking system by the California State University STEM Teacher and Researcher Program (STAR) to investigate impacts of summer research experiences for pre-service teachers on teacher induction and retention, classroom practices, teacher leadership, and networking (URL).

GM11: 2:40-2:50 p.m. Interactive Simulations in Physics Secondary Education and Student Achievement

Contributed – Muhammad Riaz, Dowling College, Long Island, Shirley, NY 11967; riazedu@gmail.com

Transporting student thinking from novice to expert, teachers should use computer simulations, which is a scientific approach to teach physics (Weiman, 2005). The purpose of this study is to examine the benefits of interactive simulations research in physics secondary education and their effects on student achievement. I will report the results yielded by the survey, which I have administered to Science, Technology, Engineering and Mathematics Teachers (STEM) of New York City-American Modeling Teachers Association (AMTA). The teachers have participated in STEM teaching practice workshops and have used simulations in their teaching practice from 2013 to 2014. The findings of this study may promote interactive learning, connecting physical phenomena with practical training, enhancing student learning, changing of classroom environment, providing opportunities to review conceptual understanding of physics. Specifically, this research study will contribute to the ongoing changes being made to the computer simulations and to changes in science instruction in general.

PST2F: Post-Deadline (Posters)

Location: SSU - Grand Ballroom Lounge
Date: Wednesday, July 29
Time: 1–2:30 p.m.

Odd number poster authors should be present 1-1:45 p.m.
Even number poster authors should be present 1:45-2:30 p.m.
(Posters should be set up beginning at 8 a.m. Wednesday and then taken down by 3 p.m.)

PST2F01: 1:45–2:30 p.m. A Comparison of Co-Teaching Models in Large-Scale Introductory Physics Courses

Poster – Jared Stang, 6224 Agricultural Rd., Vancouver, BC V6T 1Z1, Canada; jared@phas.ubc.ca

Co-teaching has been suggested as a method for dissemination of evidence-based teaching strategies and offers potential benefits for both students and faculty. [1,2] We report on two co-teaching arrangements, both involving non-PER (Physics Education Research) mid-career faculty being paired with PER faculty. Data was collected using a variety of methods, including in-class observations of instructor behaviours and student engagement, student surveys and diagnostic tests, and pre- and post-semester interviews with the faculty involved. The two arrangements adopted different co-teaching models. In the first, the instructors took a blocked approach, with a different instructor taking primary control of facilitation in each half of the semester. The second arrangement adopted a more explicitly collaborative approach, with multiple changes of control within each lecture. We will report on the differences and similarities in these two models, including instructor dynamics in the classroom, instructor perspectives, and the resulting student perspectives, engagement, and learning.

1. Henderson et al, *Am. J. Phys.* **77**: 274, 2009
2. Jones and Harris, *College Teaching* **60**: 132–139, 2012

PST2F02: 1:45-2:30 p.m. Correlating Student Backgrounds with Learning Gains for More Effective Comparisons

Poster – Brent W. Barker, Roosevelt University, 430 S Michigan Ave., Rm WB816C, Chicago, IL 60605; bbarker@roosevelt.edu

Kayla Fouch, Roosevelt University

Comparing learning gains between different offerings of the same course is helpful for studying effectiveness of instruction. In small classes, fluctuations in student background can introduce confounding variables and make direct comparison difficult. In the present work, we correlate student backgrounds with learning gains on conceptual inventories in introductory physics and show a method for accounting for differences in student backgrounds.

PST2F03: 1-1:45 p.m. The University of Maryland Electron Ring: A Compact Accelerator for Research and Student Training*

Poster – Santiago Bernal, IREAP, University of Maryland, Energy Research Facility (Bldg. #223), Paint Branch Dr., College Park, MD 20742; sabern@umd.edu

Brian Beaudoin, Irving Haber, Tim Koeth, Eric Montgomery, Kiersten Ruisard, Will Stem, David Sutter, Rami Kishek, University of Maryland

The University of Maryland Electron Ring (UMER) is a low-energy, high-current machine for research and training in accelerator and beam physics. The ongoing program includes non-linear dynamics, collective effects, and diagnostics of high-intensity beams with potential applications for advanced new particle accelerators. UMER provides research opportunities not only to graduate students at the University of Maryland, but also to many undergraduate and high school students. Students develop electronics and instrumentation, design and measure magnets for focusing and deflecting beams, write software for data acquisition and control, and do beam simulations and experiments. We describe the basic physics behind UMER and some of the contributions from undergraduate and high school students.

*Work Supported by the U.S. Department of Energy

PST2F04: 1:45-2:30 p.m. Increasing Minority Participation Through the LS-OKAMP Program at ECU

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

For over 20 years, the Louis Stokes Alliance for Minority Participation program at East Central University in Ada, OK, has been helping increase the number of minorities (primarily Native Americans) in physics and astronomy going to graduate school. Methods and results will be presented.

PST2F07: 1-1:45 p.m. Physics for Elementary Teachers; Student Framed vs. Traditional Approach

Poster – Wendy K. Adams, University of Northern Colorado, CB 133 Greeley, CO 80639; wendy.adams@unco.edu

Adrianne N. Larson, University of Northern Colorado

We will present a comparison of two very different approaches to teaching Physical Science Concepts to elementary teacher candidates. We have developed a course which is a deep look at the fundamentals of physics framed within student self reported confusion, learning and their wonderings. The literature shows that pre-service elementary teachers have lower personal interest than most, if not all, other populations that have been evaluated with the CLASS instrument. This is very concerning for the future students of these teacher candidates. In this poster data will be presented comparing this new approach with traditional instruction at our institution. Evidence of attitudes and beliefs, conceptual understanding and student opinion will be presented. We have found significant increases in personal interest of students and substantial learning gains when instruction is framed around topics the students are curious about.

PST2F10: 1:45-2:30 p.m. Physics Teaching and Interests in India – Review of Three Decades*

Poster– Kasam Ramadevi, ZPSS, Punnell, Warangal, Telangana, India 9-7-6 ELLAMMA BAZAR Waranagal, TG 506002 INDIA; mallikphd@gmail.com

It is quite obvious that a review of the interest in physical education among the student community for the past and present in any fast developing country like India may help the teacher community and might also help them in developing the nuts and bolts for fixing the system. In the present work the author reviewed and reported the above for the past three decades --1985-95, 1995-2005, and 2005-2015 in all 29 states of India. The simple statistical analysis was conducted on this data and the results were discussed. A steady significant growth in the interest in physical sciences among the students was observed during these three decades.

*This work was supported by the ZPSS and the University Grants Commission

PST2F13: 1-1:45 p.m. Student Approach to Online Homework

Poster – Andrew D. Cahoon, Colby-Sawyer College, 32 Trent Rd., Hooksett, NH 03106; acahoon@colby-sawyer.edu

The student approach to online homework assignments in introductory physics is reviewed. Attitudes, effort, and homework scores are correlated to exam performance. Student feedback comparing online and paper assignments are presented. The sample of students is primarily biology and exercise science students taking physics as a requirement for their major. We used Sapling Learning software for online homework assignments.

PST2F14: 1:45-2:30 p.m. Student Ideas Around Vector Decomposition in the Upper-Division

Poster – Anna M. Turnbull, Michigan State University, 46651 Camelia Dr., Canton, MI 48187; turnbu41@msu.edu

Leanne Doughty, Vashti Sawtelle, Marcos D. Caballero, Michigan State University

The Colorado Classical Mechanics/Math Methods Instrument (CCMI) is an open-ended assessment designed to investigate student skills in upper-division classical mechanics. With a large number of student responses compiled (N=443), we conducted an analysis of student-written work to identify student ideas and trends in student difficulties. Here, we present our examination of student responses to one CCMI question that targets vector decomposition in multiple coordinate systems. Through iterative and cooperative efforts to hand-code student responses, we identified common patterns in students' final expressions, resulting in broad categories. We identified approaches to the problem inferred from features of student solutions. For example, when decomposing a velocity vector in a Cartesian coordinate system, we found that students either differentiated a position vector or used trigonometry to visualize the components. We observed that certain approaches more commonly resulted in particular errors. Investigating productive student approaches is a step towards pedagogical improvement.

PST2F15: 1-1:45 p.m. Identifying and Analyzing Actions of Effective Group Work

Poster – Jennifer R. Keil, University of Colorado, Boulder, 2160 Buttercup St., Erie, CO 80309-0001; jenniferkeil11@gmail.com

Bridget Molloy, Rebecca Stober, Emily Quinty, Valerie Otero, University of Colorado Boulder

Research indicates that cooperative learning leads to an increase in both student achievement and motivation. Yet, instructors often encounter difficulties facilitating group work, especially at the high school level. This study investigates the characteristics of collaborative learning groups participating in the Physics and Everyday Thinking High School (PET-HS) curriculum. Video data of groups engaging in PET-HS activities were collected from eight teachers piloting the curriculum, and salient characteristics of group interactions were identified. These characteristics were organized into a continuum rubric, which provides indicators to suggest the level at which groups are functioning. Reliability and consistency of this tool were assessed. The continuum rubric can then be utilized in the classroom to gauge the current state of group dynamics and inform future interventions to advance student groups along the continuum. Implications for assessing group dynamics, efficacy of interventions, and student achievement will be discussed.

PST2F16: 1:45-2:30 p.m. Outcomes and Effects of a High School Physics Teacher Professional Development Program

Poster – Donna Stokes, University of Houston, 617 Science and Research #1, Houston, TX 77204-2018; dstokes@uh.edu

Milijana Suskavcevic, Rebecca Forrest, Andrew Kapral, Paige Evans, University of Houston

Seventeen physics teachers participated in a year-long, intensive (120 contact hours), and sustained professional development program in physics at the University of Houston during the academic year 2014-15. The professional development program was focused on building physics teachers' content and instructional skills, and was supported by peer mentoring, materials, and technology. The professional development program is a part of broader Community of Practice which involves University of Houston's STEM Teaching Equity Project (STEP), College of Natural Sciences and Mathematics, and Houston area school districts. Concept tests (electricity & magnetism, waves, and modern physics) and surveys of instructional strategies were used to document participants' changes in cognitive and affective outcomes before and after the intervention. We will discuss the participants' outcomes, and additionally share some unanticipated effects on physics faculty, which resulted from their active participation in the Community of Practice.

PST2F17: 1-1:45 p.m. First Experiences with Honors Physics in a Two-Year College

Poster – Sherry L. Savrda, Seminole State College of Florida, 100 Weldon Blvd., Sanford, FL 32773; savrdas@seminolestate.edu

This poster will describe the trials and tribulations of establishing an Honors Physics sequence at a two-year college. Details of planning and implementation will be provided. In addition, student projects that resulted from the course will be described. Successes, challenges, and plans for the future will be included.

PST2F18: 1:45-2:30 p.m. Development and Implementation of Tutorial-like Active Learning in Japan

Poster – Yoshihide Yamada, University of Fukui, 3-9-1 Bunkyo Fukui, 910-8507 Japan; yamada.heart@gmail.com

In Japan, reformations of physics classes influenced by Physics Education Research have been spreading only recently. The author, as a novice university teacher, developed an introductory optics curriculum (worksheets) based on Physics Education Research and has implemented it over the four years. These classes are provided as a course of general education. So the content of this curriculum was made concept-oriented and contains only popular topics such as rectilinear propagation of light, plane and curved mirrors, and convex and concave lenses. In addition, the technique of parallax is explicitly treated as an essential observation skill to locate an image, though it is uncommon in Japan these days. The class style is tutorials-like which follows Washington's and Maryland's. But it does not accompany a lecture class. It consists exclusively of group work. The gains of these classes were between 0.33 and 0.44. I will report the remaining problem on this curriculum.

PST2F19: 1-1:45 p.m. Ideas of Astronomy and Physics Students

Poster – Bethany Reilly, University of Wisconsin-Fox Valley, 1478 Midway Rd., Menasha, WI 54952; bethany.reilly@uwc.edu

Students in introductory courses of astronomy and physics were surveyed regarding their ideas about science, and in the case of the physics students, their understanding of physics concepts. Surveys were given at the beginning and end of the semester. Results are broken down by gender and whether the student is a STEM field major. The astronomy students mostly had no prior astronomy experience. They were asked about their impressions on the ease or difficulty of learning astronomy, as well as questioned regarding their ability to differentiate between astronomy and astrology. The physics students were in their second semester of physics. They were asked about their ideas regarding what it means to learn and do physics, as well as questioned regarding their knowledge of certain classical mechanics and electricity and magnetism topics.

PST2F20: 1:45-2:30 p.m. Methods for Displaying Mobile Devices for Classroom Use

Poster – Corey Gerving, United States Military Academy, Science Center, Bldg. 753, West Point, NY 10996; corey.gerving@usma.edu

One of the challenges faced by users of mobile devices is how to project your screen for others to see. (Without this capability, many would argue that your mobile device is nothing more than an expensive notebook.) This poster will describe several different methods for institutions to implement to allow for maximum flexibility in the use of mobile devices on their campuses. It will also present the user with some easy options they can implement if they find themselves in need of a projection platform.

PST2F22: 1:45-2:30 p.m. Metacognition Activities Infusion in Intro Physics: Effective and Simple

Poster – Sara Kathrine Julin, Whatcom Community College, 237 W. Kellogg Rd., Bellingham, WA 98226; sjulin@whatcom.ctc.edu

Andrew Boudreaux, Western Washington University

Research shows that successful problem solvers actively practice metacognition. However, the self-monitoring and self-questioning that makes up metacognitive practice is largely private, and is rarely modeled or valued explicitly in high school and college STEM courses. Physics teachers face enormous challenges helping students develop metacognitive skills. If significantly evolved metacognition ability is a key to how people successfully learn, then how can we help students recognize, practice, and build on their emerging metacognitive skills? What kinds of manageable changes to instruction can help students improve these skills in the context of the learning physics? This poster discussion will highlight several strategies that I have used successfully in the introductory calculus-based course, with a range of students having very low to high entry skills. The presentation is intended to provide practical examples of instructional actions that can support metacognitive practice and be woven into the daily life of physics students.

PST2F24: 1:45-2:30 p.m. Comparison of Active Learning Technologies vs. Traditional Lecturing

Poster – Branislav R. Djordjevic, George Mason University, 4400 University Dr., Fairfax, VA 22030; bdjordje@gmu.edu

Maria Dworzecka, Jason Kinser, George Mason University

Beginning with the fall 2013 semester, George Mason University began teaching first semester (PHYS-160) and second semester (PHYS-260) calculus-based physics courses in an ALT (active learning technologies) environment simultaneously with traditional lectures. Previous results of students' performance comparisons consistently showed that ALT courses were more effective means for students' learning than traditional lecturing. Average final grades, as well as the average exam grades in ALT courses regularly surpassed grades in traditional courses by 10-15%. We also cross-compared performance of our students in the PHYS-260 course in all four combinations of students coming from PHYS-160 TRAD, or ALT course to either style of the PHYS-260 courses. We did our analysis for all available pairs of consecutive semesters starting from fall 2013 and ending with spring 2015. Results from this analysis clearly indicate that students' performance is greatly improved through the ALT experience.

PST2F25: 1-1:45 p.m. Two Simple Projects from a Unique Optics Teaching Laboratory

Poster – John Noe, Stony Brook University, Department Physics & Astronomy, Stony Brook, NY 11794-3800; johnnoe@gmail.com

The Laser Teaching Center at Stony Brook University is a unique educational environment in which young students (over half female) are introduced to research by creating and documenting simple but open-ended hands-on optics-related projects in collaboration with a mentor. (See my papers from ETOP 2007 in Ottawa.) We will describe two such recent projects by freshmen undergraduates that could be useful in more traditional instruction. Jasmine's project involved creating Maltese cross polarization patterns with readily available birefringent materials. Max's project provided an introduction to the rich optics of Fresnel diffraction by examining the light field near a 0.5 mm aperture with a 10x microscope objective. Other recent somewhat more advanced projects (some by full-time summer high school students) have involved the mode structure of HeNe lasers, the creation of Airy beams, and trapping forces in optical tweezers. The tweezers project was recognized by an Intel Finalist award, our third in 15 years.

PST2F26: 1:45-2:30 p.m. The Importance of Computational Physics Education: An Undergraduate Perspective

Poster – Matthew S. Parsons, Undergraduate Physics, Drexel University, 536 Alexander Rd., Princeton, NJ 08540; msp73@drexel.edu

The incorporation of computational physics coursework into the undergraduate curriculum is a challenge, but one that can't be ignored. Throughout my undergraduate career, my own experience with Drexel's curriculum in this area has proven to be invaluable in my development as a physicist. As a case study, I'll give my perspective as a graduating physics student with examples of computational coursework throughout my four years at Drexel.

PST2F27: 1-1:45 p.m. The Effect of Reading Quizzes for Introductory Physics Courses

Poster – Colleen L. Countryman, North Carolina State University, PO Box 8202, Raleigh, NC 27606; cblanz@ncsu.edu

Lili Cui, North Carolina State University

Pre-class reading assignments have been a common feature of flipped classrooms. In this study, we investigate the educational impact of these reading quizzes by using two identical sections taught by the same instructor and given the same homework assignments and exams. The control section has no reading quizzes while the experimental section was asked to complete weekly online pre-class reading quizzes. As shown in the quantitative comparison of the daily Clicker questions and the exam grades of these two sections, the experimental section overall performed better than the control section. Survey data from the beginning and middle of the semester indicate that the majority of the students in the experimental section appreciate the benefits of the readings quizzes. We will also discuss how best to improve these reading quizzes in future implementations.

PST2F30: 1:45-2:30 p.m. A Key for Team Exams: Balanced Teams

Poster – Hyewon Jang, Harvard University, 29 Oxford St., Cambridge, MA 02138; hwjang@seas.harvard.edu

Eric Mazur, Harvard University

Assessments can be used to improve students' problem solving. However, current physics education using only individual assessment has limitations to improve students' achievement. A few studies have reported that the greater effect on student learning of collaborative testing, however, educational efforts for fair team exams were not fully addressed. We applied five blended exams to evaluate undergraduate students' physics problem-solving skills with two-step processes; an individual exam and then a team exam with instant feedback using an online response system. We find that team scores in team exams are significantly correlated with the average of individual scores, the standard deviation of individual scores, and the best-in-team student's score in a team. In our conclusion, forming balanced teams is the first condition for fairness and effectiveness in team exams.

PST2F31: 1-1:45 p.m. College Students' Awareness About Pseudoscience and Understanding of Physics Concept

Poster – Sungmin Im, Daegu University, Department of Physics Education, College of Education, Daegudae-ro 201 Gyeongsangbukdo, 712714 South Korea; ismphs@daegu.ac.kr

Promoting students' scientific literacy has been one of the most important objectives of physics education at all levels, but many students can easily meet various pseudoscience such as clairvoyance, astrology through mass media like TV, Internet, newspapers, and so on. So it is necessary to identify what extent students believe in pseudoscience and how such beliefs may affect their learning physics. For this reason, the authors investigated students' awareness about pseudoscience based on a previous study and also measured their understanding of physics concepts using the FCI. And then, the authors identified the correlation between the awareness about pseudoscience and the understanding of physics concepts. 101 freshmen from science and engineering in Korea were involved in this study. As a result, college students' awareness about pseudoscience showed negative correlation with conceptual understanding of physics, but it had no correlation with typical misconception in physics.

PST2F32: 1:45-2:30 p.m. Feline Statistics & Exponential Behavior

Poster – Patricia E. Allen, Appalachian State University, PO Box 57, Sugar Grove, NC 28679; allenpe@appstate.edu

Many introductory and upper-level physics students have difficulty applying statistics to make meaningful comparisons between values, especially in laboratory settings. In addition, students are often uncomfortable using exponential functions to model growth or decay in physical systems. Information from AVMA (American Veterinary Medical Association) and APPA (American Pet Products Association) publications demonstrate large and small number statistics dealing with the total number and lifespans of owned felines in the United States. In contrast, controlling feral cat population (~# of owned cats) showcases the power of exponential behavior. Using these and other examples, the role of feline statistics and exponential behavior in appropriate courses will be presented and discussed, including some suggestions for student assignments.

PST2F33: 1-1:45 p.m. HS/UG Observational Research at the UMD Observatory

Poster – Elizabeth M. Warner, University of Maryland, 400 Madison St. #2208, Alexandria, VA 22314; warnerem@astro.umd.edu

In 2013, the UMD Observatory transformed its Explore the Universe class from a service-learning project into a hands-on, experiential research project for undergrads and high school interns. Each year since 1997, the UMD Observatory has hosted a small number of sophomores from the College Park Scholars Science Discovery and the Universe (SDU) program working on their capstone projects. The class, Explore the Universe, was originally designated as "Service Learning" because, in addition to the college students, there were also several high school students. The college students mentored the high school students through their science fair projects. Over the years, participation by college and high school students declined due to various reasons. During the 2012-2013 academic year, we had no students. This forced us to rethink how we carried out student research. We will present how we transformed the class and the research opportunities available at the UMD Observatory.

PST2F34: 1:45-2:30 p.m. Integrating Student Feedback into Inquiry-based Physics Laboratory Experiences

Poster – Tracy Cator-Lee, George Mason University, 4400 University Dr., MSN3F3, attn: Mary Ewell, Fairfax, VA 20148; tcatorle@gmu.edu*

Mary Ewell, George Mason University

Over the last decade interest in potential benefits of inquiry-based labs has increased substantially. George Mason University presently offers laboratories in both traditional and inquiry-based formats. In an effort to gauge students' perceptions of these two distinct styles, assessments were created and given to students near the end of the spring 2015 semester. It has long been understood that traditional laboratories fail to engage students or activate their critical thinking skills. It is also known students may resent the extra work required to complete the inquiry-based format. By reviewing student feedback, the laboratory experience can be modified to maximize students' enthusiasm. Through inquiry in the laboratory and feedback modifications, students will approach scientific questions and develop effective experimental strategies to resolve them.

*Sponsored by Mary Ewell

PST2F35: 1-1:45 p.m. Nanoscience: Working with Matter at the Nano-scale

Poster – Krithika Venkataramani, Elon University, 100 Campus Dr., Elon, NC 27244-2010; krithika1984@gmail.com

Nanoscience is the study of physical phenomena and systems at the nanometer scale (1-100 nm). The current progression of technology toward miniaturization has made Nanoscience the most dynamic and rapidly evolving multidisciplinary field in applied physics. A study by NSF predicted that six million Nanotechnology workers will be needed by 2020 with two million in the U.S. alone. Nanoscience has already gained huge importance in higher education research. Many efforts are currently directed towards early engagement of students in exploration of Nanoscience topics in high school and undergraduate institutions using affordable bench-top state-of-the art nanoprobes. I will present in my poster various interesting aspects of nano-scale physics; important nano-characterization techniques; current state of research in some important areas; and finally, examples of a few successful initiatives undertaken by universities to integrate hands-on Nanoscience activities in their existing undergraduate curriculum.

PST2F36: 1:45-2:30 p.m. Pathways to Solve an Estimation Problem; Engineering or Physics

Poster – Hyewon Jang, Harvard University, 29 Oxford St., Cambridge, MA 02138; hwjang@seas.harvard.edu

Petter Holme, Sungkyunkwan University

Eric Mazur, Harvard University

Estimation requires one to make assumptions based on one's knowledge and experience. However, pathways of students' solving estimation problem have not been reported yet. We collected data from 84 undergraduate students to solve an estimation problem as an assignment. In this study, first, we illustrate that pathways of students' solving an estimation problem are diverse. Second, using network analysis, we visualize the distribution of pathways with the similarity in the personal background. Third, we identify the tendency of pathways to solve an estimation problem according to students' backgrounds; engineering students tend to seek optimal process, but students who learn physics tend more to think of a big picture first.

PST2F37: 1-1:45 p.m. Physics Wonder Girls: Sustaining Interest in STEM Among Middle School Girls*

Poster – Roberto Ramos, Indiana Wesleyan University, 4201 South Washington St., Marion, IN 46953; robertoramos99@hotmail.com

To contribute to sustaining the pipeline of girls interested in STEM, the broader impact component of an NSF-sponsored grant in condensed matter physics consisted of a novel Physics Day Camp for Middle School Girls in Central Indiana. Dubbed "Physics Wonder Girls," the annual camp consisted of three full days of activities designed to intensity and sustain interest in physics of a select cohort of eighth grade girls identified by science teachers from the community. The camp has been offered free of charge over a period of three years on the campus of Indiana Wesleyan University. An inter-disciplinary student crew helped participants experience hands-on experiments, demonstrations, problem-solving, and activities surrounding different themes including building and operating a submersible, buoyancy, materials science, superconductivity, and nanotechnology. Other notable signatures of the camp include a women-only discussion led by a panel of female STEM researchers, a colorful classroom decorated with pictures and information about women STEM models and with encouraging adjectives buoying up girls' interest in STEM, and a capstone Physics Show given by participants to their families, friends and teachers. In this presentation, insights, observations and lessons learned regarding the mechanics of conducting such STEM programs for middle school girls will be shared. The Physics Wonder Girls camp has been cited nationally by the Society of Physics Students, by the local media, and is registered with the National Girls Collaborative Project (NGCP).

*This material is based upon work supported by the National Science Foundation under Grant Number #1206561.

PST2F38: 1:45-2:30 p.m. Teaching for Deep Learning: Facilitating Classroom Discourse in a Model-Centered Physics Classroom

Poster – Mark Lattery, University of Wisconsin, Oshkosh 800, Algoma Blvd. Oshkosh, WI 54902-6945; lattery@uwosh.edu

Christopher Christopherson; University of Wisconsin Oshkosh

Science learning is greatly enhanced when science teaching reflects scientific practice. An important aspect of this practice is discourse between scientists during the discovery process. It is therefore natural to ask what teacher-guided student discourse can contribute to science learning. The purpose of this poster is to review recent research, resources, and practical tips for facilitating discourse in a model-centered physics classroom. Special attention is given to strategies that elevate the quality and quantity of student interactions during large-group whiteboard discussions.

PERC Bridging Session

Location: SSU - Hoff Theater
Sponsor: AAPT
Date: Wednesday, July 29
Time: 3–4:30 p.m.

Presider: Benjamin M. Zwickl

3-3:20 p.m. Welcome to PERC 2015 with an Overview of the Theme and Sessions

PERC Organizing Committee

3:20-3:55 p.m. Challenges and Opportunities for Measuring Student Outcomes of Undergraduate Research

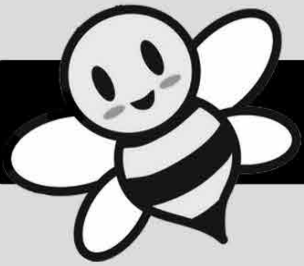
Sandra Laursen, Ethnography & Evaluation Research, University of Colorado

Inherent in the practice of apprentice-model undergraduate research (UR) is a fundamental tension between the educational goals of UR and its basis in faculty scholarship. This tension leads to challenges for faculty in guiding student researchers in their daily work and in positioning their own UR work within institutionally bifurcated domains of teaching and research. It also generates a disconnect when it comes to measuring the outcomes of UR. Traditional outcome measures emphasize students' career outcomes and research productivity, while education research has documented students' personal and professional learning from UR, including new skills and understandings of disciplinary inquiry, growth in confidence and responsibility, and scientific identity development. Thus far, self-report measures including surveys and interviews have dominated this young body of research. I will discuss why assessing the outcomes of apprentice-model undergraduate research is inherently difficult, outline the strengths and limitations of the approaches tried to date, and suggest areas for future research.

3:55-4:30 p.m. Labs as a PER Playground for Concept, Critical Thinking, and Epistemology Development

Natasha Holmes, Physics Department, Stanford University

While the goals for instructional labs have been highly debated, inquiry- and skills-driven labs can lead to significant gains in students' scientific and experimentation abilities. In this talk, I will present an example of such a lab pedagogy that uses uncertainty and data analysis skills as a springboard for developing students' epistemologies, experimentation behaviours, and critical thinking abilities. By engaging in structured cycles of comparisons and measurement improvements, students explore the limits of physical models in the real world and engage in the evaluation and refinement of these models. In a controlled research study, students adopted these behaviours and continued to use them even after instruction to do so had been removed. From these and other outcomes, I will argue for labs as a rich PER environment with many open and exciting questions awaiting the skills of the community.



AAPT Welcomes First Time Attendees

Come and check out the latest buzz and meet other newbies at the "Bee Hive" aka the **First Timers' Breakfast** on **Monday, July 27 from 7:00-8:00 am.**

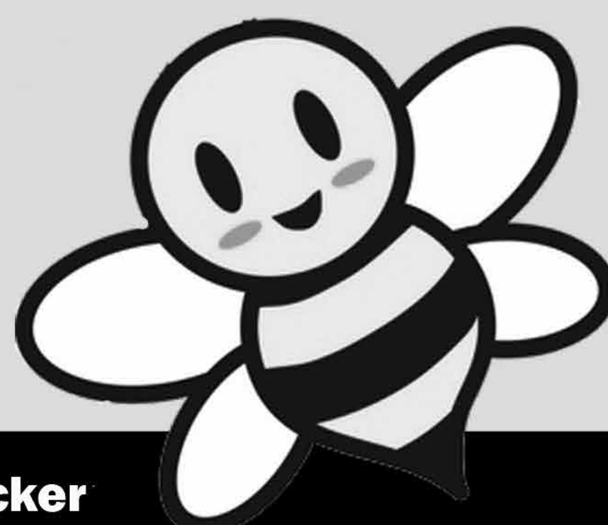
This is the best time to learn about AAPT and the Summer Meeting, as well as meet fellow newbies. AAPT leadership will be represented to discuss ways to get more involved. Don't forget to join us for a **First Timers' Meet-up** on **Monday, July 27 from 6:15-7:15 pm**.

Not Sure Who's New?

Rest assured you'll be able to easily spot other First Time Attendees, from the "newbie/bee" stickers on their badges. Make sure to grab one at the registration desk or the AAPT booth!

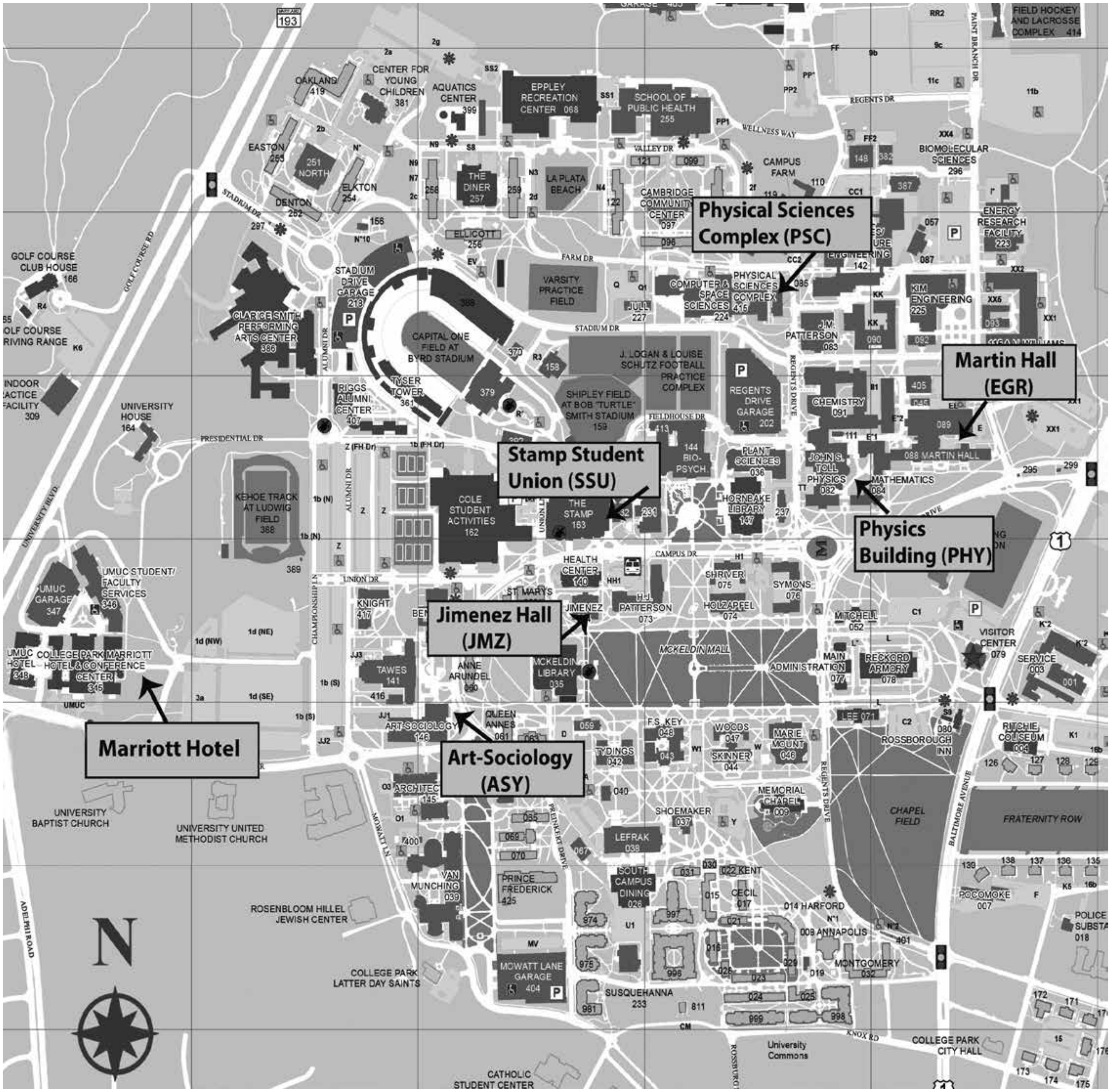
Calling All AAPT Veterans!

While we have put a lot of work into these new initiatives for our first timers, we still need your help as an AAPT Meeting veteran. The best way for you to help is simply to connect. If you see a first timer, say hello! Introduce them to some of your contacts. Not only will you be helping the first timers, but you'll be building your own network and quite possibly making a great new friend!



"Bee" on the lookout for this sticker

Index of Participants



University of Maryland

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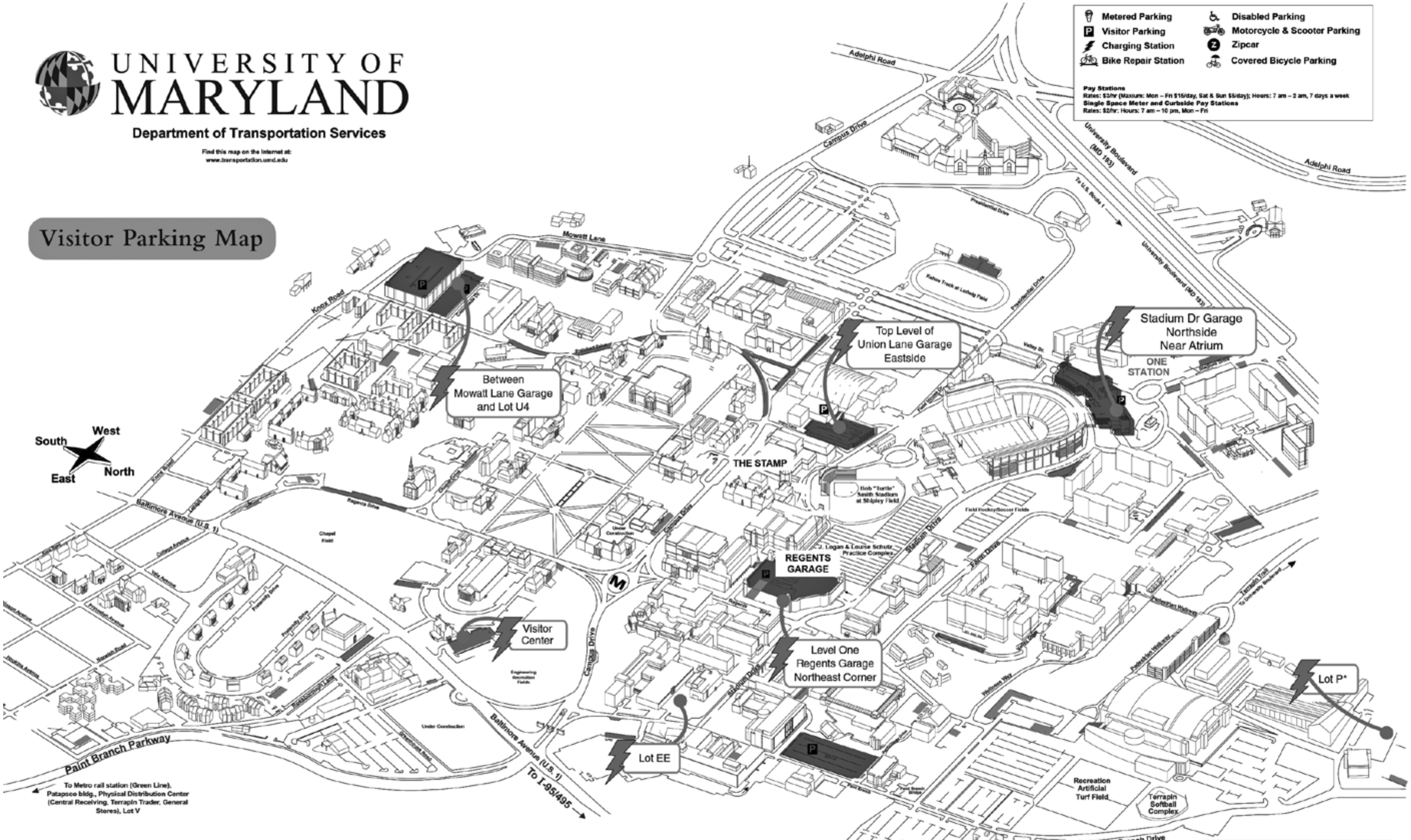
UNIVERSITY OF MARYLAND

Department of Transportation Services

Find this map on the Internet at: www.transportation.umd.edu

Visitor Parking Map



SURFACE/STREET LOCATIONS

HOURS

MONDAY-FRIDAY 7:00AM - 10:00PM

RATES

MONDAY-FRIDAY

$2.00 ONE HOUR

- Multi-Space Pay Stations - accepts cash and credit cards
- Single Space Meters - only accept credit cards/debit cards

GARAGE/VISITOR PARKING LOTS

HOURS

DAILY 7:00AM-2:00AM

Mowatt Lane Garage (top level), Union Lane Garage, Stadium Drive Garage (portions), Regents Drive Garage (portions), Paint Branch Visitors Lot (FREE on weekends)

RATES

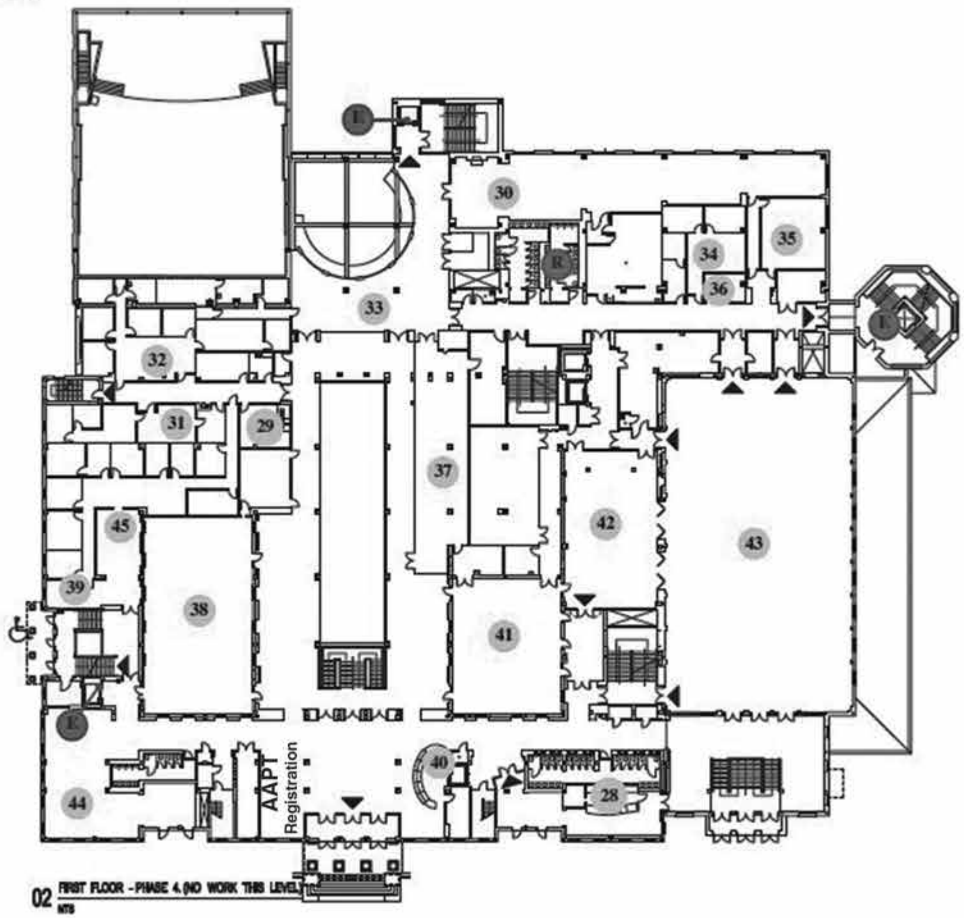
MONDAY-FRIDAY	WEEKENDS
$3.00 ONE HOUR	$3.00 ONE HOUR
$15.00 MAXIMUM DAILY	$5.00 MAXIMUM DAILY RATE
	*Paint Branch Lot is Free

ELECTRIC VEHICLE

CHARGING STATION

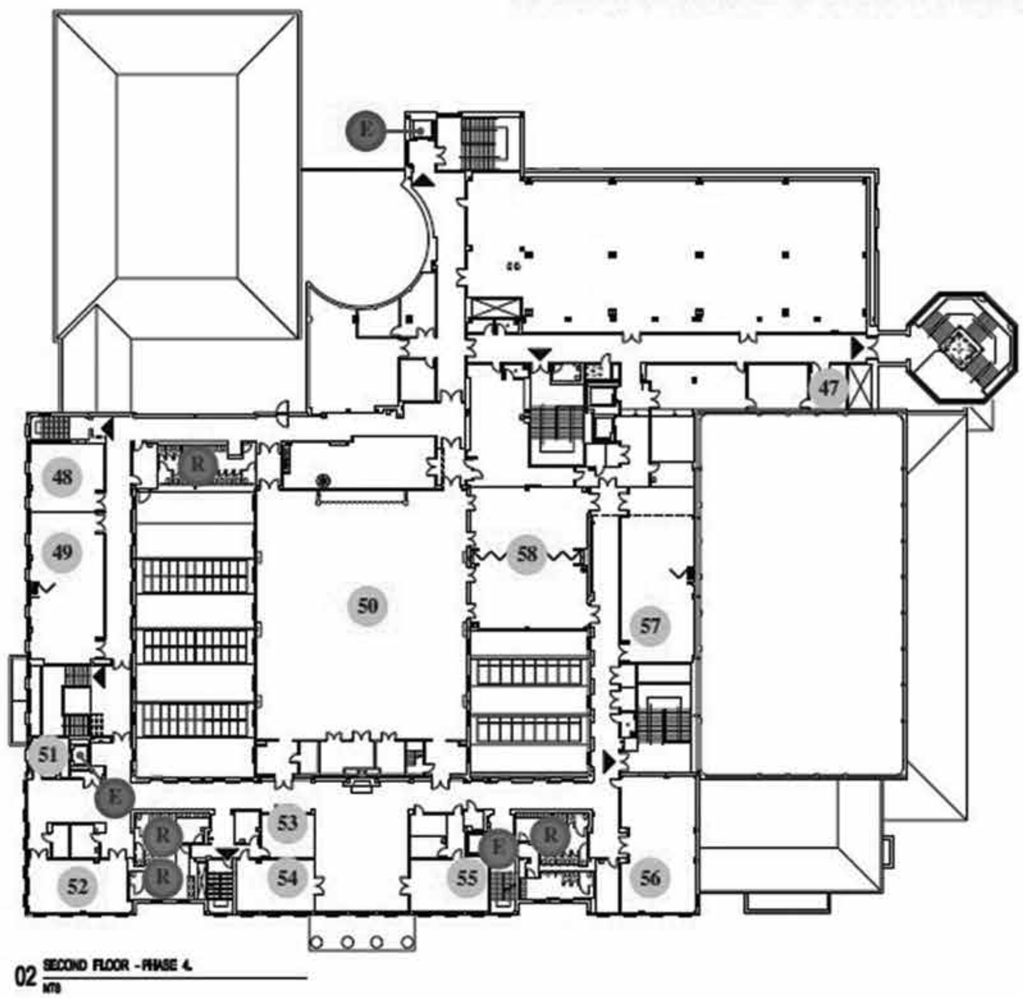
Stamp Union FIRST FLOOR

28 – Coffee Bar (1203)
29 – Multicultural Involvement & Community Advocacy (1120)
30 – Adele's (1240)
31 – Graduate Student Suite (1121)
32 – Event Services/Marketing
33 – North Court (1482)
34 – Undergraduate/Graduate Legal Aid (1235)
35 – Nanticoke Room (1238)
36 – Marketing Asst. (1236)
37 – Stamp Gallery (1220)
38 – Atrium (1107)
39 – Off Campus Housing (1110)
40 – Information Desk (1201)
41 – Prince George's Room (1210)
42 – Grand Ballroom Lounge (1209)
43 – Grand Ballroom (1206)
44 – Reading Room (1105)
45 – Office of Fraternity & Sorority Life (1110)
R – Restrooms
E – Elevator



Stamp Union

SECOND FLOOR



Second Floor

47 – Technology Services - IT Help/ Audio Visual Services (2220)
48 – Thurgood Marshall Room (2113)
49 – Margaret Brent Room (2112)
50 – Colony Ballroom (2203)
51 – Harriet Tubman (2110)
52 – Pyon Su Room (2108)
53 – Edgar Allen Poe Room
54 – Calvert Room
55 – Crossland Room
56 – Juan Ramon Jimenez Room
57 – Benjamin Banneker Room
58 – Charles Carroll Room
R – Restrooms
E – Elevator

Exhibit Hall SSU - Grand Ballroom

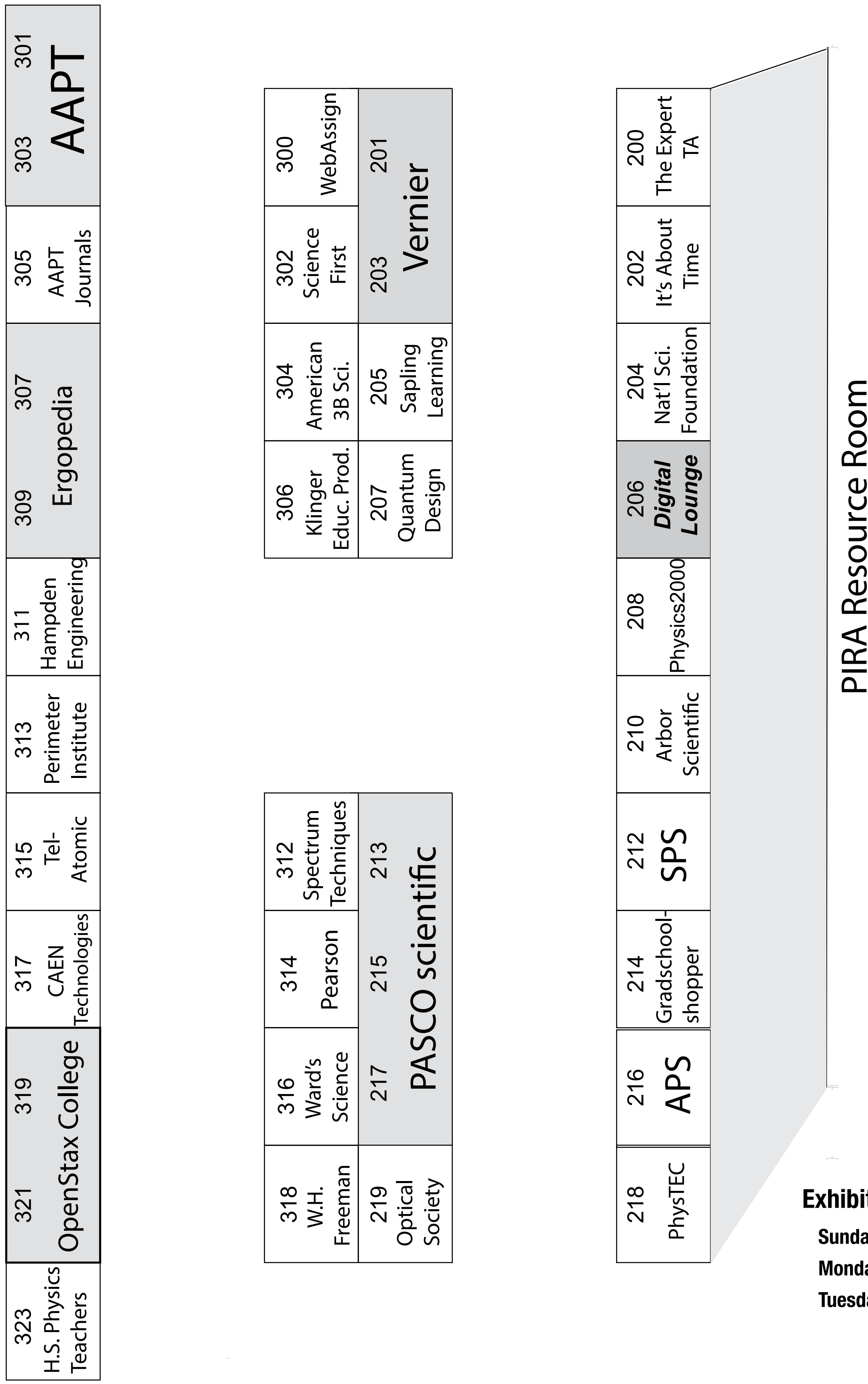


Exhibit Hall Hours

Sunday, 8–10 p.m.

Monday, 10–5

Tuesday, 10–4

JOIN THE CONVERSATION
#AAPTSM15

American Association of Physics Teachers

Application for the Bauder Fund Endowment for the Support of Physics Teaching

Contact Information		
Name:		
Address:		
City:	State:	Zip:
Phone:	Fax:	
E-Mail:		

Proposal

The Bauder Fund will consider applications that request funds for:

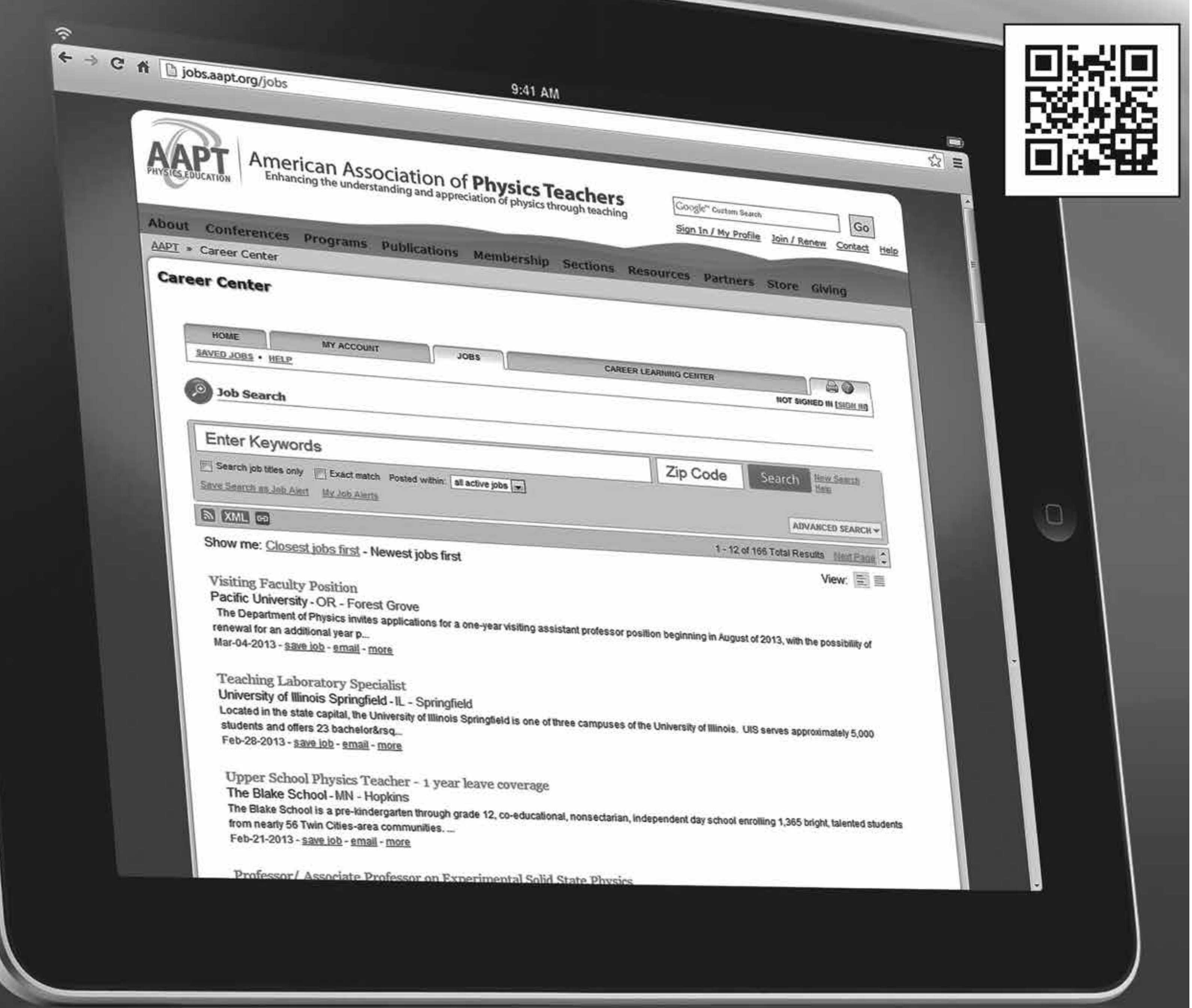
- Providing grants for the development and distribution of innovative apparatus for physics teaching.
- Providing funds to obtain and or build and support traveling exhibits of apparatus.
- Providing funds for local workshops. Up to $1000 to fund local workshops for teachers who spread the use of demonstration and laboratory equipment.
- Providing support for grant projects provided the Bauder Fund Committee recommends such projects and the AAPT Executive Board approves them.
- The Bauder fund will support purchase of supplies for workshops, liability insurance for workshops and demonstration programs.
- The Bauder fund cannot support indirect or administrative costs, travel, lodging, food for presenters or participants, or equipment that would normally be available in a school or department.
- The Bauder fund will reimburse approved expenses supported by original receipts and claimed on a report of the activity submitted to the AAPT Programs Department.
- Dissemination of results of the activity is expected. Suitable methods are talks or posters presented at state or national AAPT meetings, articles written for the AAPT *eNNOUNCER*, for *The Physics Teacher*, or the *American Journal of Physics*.

Please include a description of your project, a time line, your expertise in administering the project, and an itemized budget. Proposals are considered by the Bauder Fund Committee at the Winter and Summer meetings. Proposals must be received by December 1 for the Winter Meeting and July 1 for the Summer Meeting. Proposals should not exceed two pages in length.

Reimbursement of Funds

To receive funds from the Bauder Fund, the recipient must send original receipts for materials purchased to AAPT. Contact the AAPT Programs Department at (301) 209-3340 for any questions.

Mail completed application to:
AAPT Programs
One Physics Ellipse
College Park, Maryland 20740-3845
Fax: (301) 209-0845 • E-Mail: programs@aapt.org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1. Download the app by going to https://crowd.cc/s/4uMA, or search the "Apple" or "Google Play" stores for AAPT, American Association of Physics Teachers.

2. Open the app and tap on 2015 AAPT Summer Meeting (SM15).

Upload your contact information into the meeting app and you will be entered into a drawing for a $100 American Express Gift Card.

CrowdCompass

We'll see you in New Orleans!

2016 AAPT Winter Meeting
January 9–12

aapt.org/Conferences/meetings.cfm

. . . and/or in Sacramento!

2016 AAPT Summer Meeting
July 16–20

Courtesy of the Sacramento Convention and Visitors Bureau


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