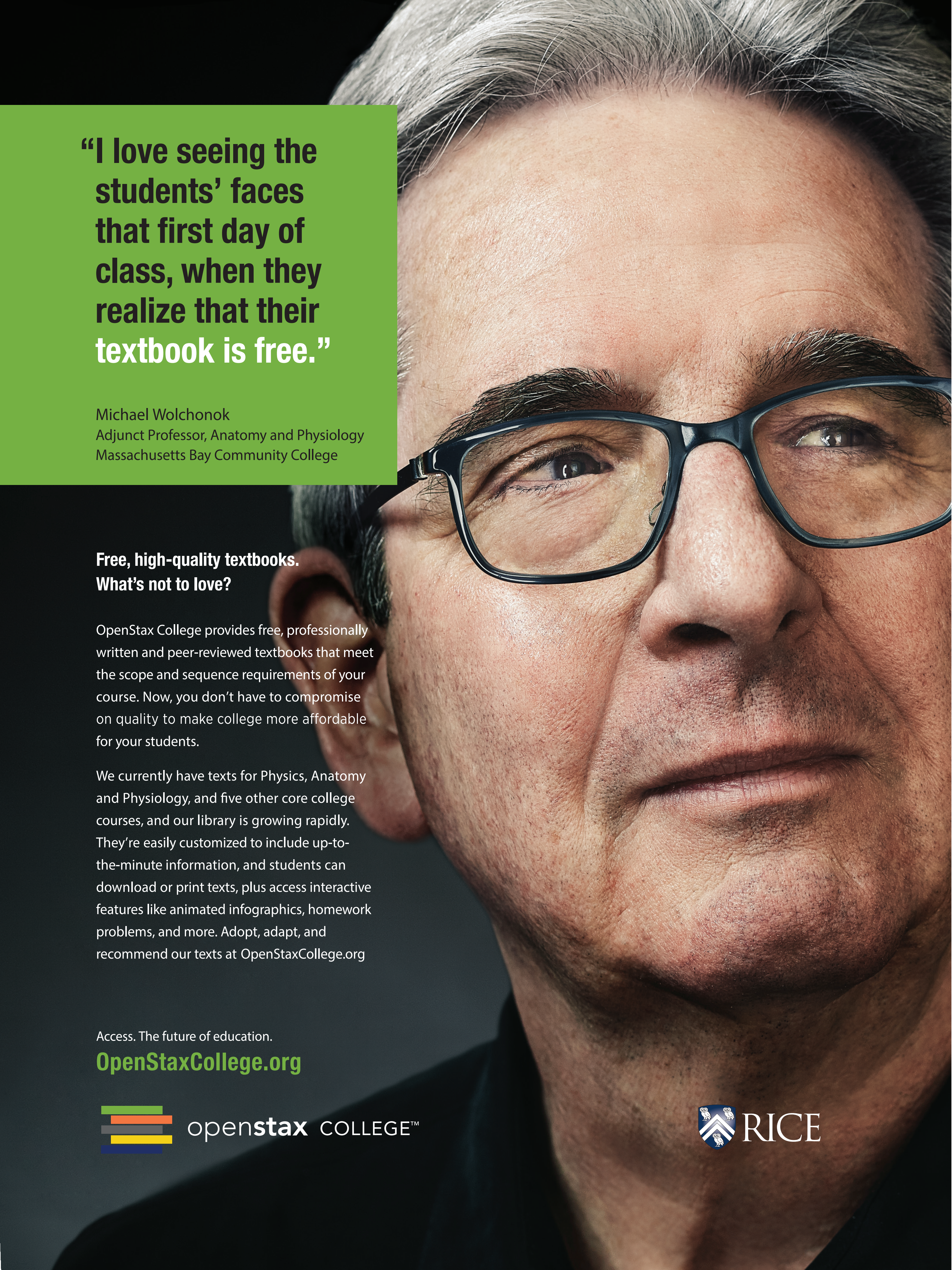
2014 AAPT Summer Meeting Program Guide

AAPT American Association of Physics Teachers

Minneapolis, Minnesota
July 26–30th


"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
Free, high-quality textbooks.
What's not to love?
OpenStax College provides free, professionally written and peer-reviewed textbooks that meet the scope and sequence requirements of your course. Now, you don't have to compromise on quality to make college more affordable for your students.
We currently have texts for Physics, Anatomy and Physiology, and five other core college courses, and our library is growing rapidly. They're easily customized to include up-to-the-minute information, and students can download or print texts, plus access interactive features like animated infographics, homework problems, and more. Adopt, adapt, and recommend our texts at OpenStaxCollege.org
Access. The future of education.
OpenStaxCollege.org
openstax COLLEGE™
RICE

Welcome to Minneapolis....................... 3
Meeting Information............................ 4
First Time at a Meeting? 6
About Minneapolis................................ 8
Meeting at a Glance 10
Special Events 14
AAPT Awards.. 16
Plenaries 20
Committee Meetings............................ 22
Commercial Workshops......................... 23
Exhibitor Information........................... 25
Sessions Schedules............................... 28
Workshop Abstracts 32
Session Sponsors.................................. 40
Session Abstracts 43
  Sunday 43
  Monday 47
  Tuesday 91
  Wednesday 125
Participants' Index 152
Advertisers' Index 155
Maps 156

JULY 26-30

AAPT 2014
PHYSICS EDUCATION
SUMMER MEETING MINNEAPOLIS, MN

Minneapolis, MN
July 26-30, 2014

The University of Minnesota

AAPT
PHYSICS EDUCATION

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

Welcome to Minneapolis

The 2014 Summer Meeting celebrates the fun of physics and physics teaching. The University of Minnesota will be a great on-campus venue, with workshops and sessions being held in university buildings. The 2014 Summer Meeting is a time to meet with old friends and make new ones. I hope that you've also scheduled some time to attend some great pre- and post-meeting events. In addition to the PTRA pre-conference, there is a Friday July 25th tour to the Soudan and NOVA neutrino detectors. The post-meeting PERC starts the afternoon of Wednesday, July 30th and runs through Thursday. Also, after the close of paper sessions Wednesday afternoon, there is a Mall of America Tour and a Zooniverse classroom demonstration event.

At the meeting there are great plenary and award talks. Monday will feature the teaching awards and Distinguished Service Citations and the introduction of the AAPT Fellows program. The Zitzewitz Award will be given to Bradford Hill. Ruth Chabay and Bruce Sherwood will receive the Halliday and Resnick Award. Jim Kakalios, Monday's plenary speaker, is the author of *The Physics of Superheroes* and *The Amazing Story of Quantum Mechanics.* Tuesday will feature the Klopsteg Award given to Donald Olson and the APS Plenary sponsored by the Division of Particles and Fields. Talks this year by Roger Rusack, Lucy Fortson, and Dan Cronin-Hennessy will be about the LHC, dark energy, and neutrinos, respectively. Eugenia Etkina will receive the Millikan Medal on Wednesday.

Special events begin Sunday with the evening Opening Reception. Monday is the High School Teachers' Day and the schedule is packed with events and sessions of particular interest to high school teachers. Also on Monday are the First Timers Gathering, Early Career Professionals Speed Networking, and the Melba Toast. The semi-annual Fun Run/Walk, Trolley Tour of Minneapolis, Demo show, and Pub Crawl will be held Tuesday.

With poster sessions, approximately 45 workshops, 70 paper sessions, and 11 Topical Discussions, there is something of interest for everyone. I encourage you to attend one or more of the 18 area committee meetings, which are open to all. Don't forget to stop by the exhibit hall to thank our exhibitors and view their wares—and for "second breakfast."

Summer Meeting 2014 should be a great meeting. I hope that you experience the fun of physics and physics teaching.

Enjoy!

Mary Mogge

Program Chair 2014 Summer Meeting – Minneapolis
President Elect, American Association of Physics Teachers

AAPT Sustaining Members

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

American 3B Scientific
Arbor Scientific
AU Physics Enterprises
CourseWeaver
Educational Innovations
Expert TA
Iowa Doppler Products
Klinger Educational Prod Corp
Lab Connections
Laser Classroom
Liti Holographics
Modus Medical Devices Inc
Oceanside Photo & Telescope
PASCO scientific
Perimeter Institute for Theoretical Physics
Physics2000.com
Plot.ly
Sapling Learning
School Specialty Science (CPO Science)
The Science Source
Spectrum Techniques LLC
TeachSpin Inc
Tel-Atomic Inc
Triangle Coalition
Vernier Software
W H Freeman & Company
Ward's Science
WebAssign

Special Thanks

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

Ken Heller, Sean Albiston, Brian Andersson, and Leon Hsu – School of Physics and Astronomy, University of Minnesota

Paper sorters:

Janelle Bailey – Vice President of AAPT and Program chair for WM15
Kathy Harper – Rep. for the Committee on Research in Physics Education
Leon Hsu – Rep. for the Committee on Research in Physics Education
Toni Sauncy – Director, Society of Physics Students
Kendra Sibbernsen – Chair, Committee on Physics in Two-Year Colleges

AAPT Executive Board

Steven Iona, President
University of Denver
Denver, CO

Mary Elizabeth Mogge, President Elect California State Polytechnic University, Pomona, CA

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

Wolfgang Christian, Secretary
Davidson College
Davidson, NC

Steven Turley, Treasurer
Brigham Young University
Provo, UT

Gay B. Stewart, Past President
University of Arkansas
Fayetteville, AR

Gregory Puskar, Chair of Section Representatives
West Virginia University
Morgantown, WV

Elaine Gwinn, Vice Chair of Section Representatives
Shenandoah High School
Middletown, IN

Jan Mader, at large (High School Representative)
Great Falls High School
Great Falls, MT

Aaron P. Titus, at large (4-Year College Representative)
High Point University
High Point, NC

Paul Williams, at large (2-Year College Representative)
Austin Community College
Austin, TX

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

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

Beth A. Cunningham (ex officio)
AAPT Executive Officer

Robert C. Hilborn (guest)
AAPT Associate Executive Officer

Facebook/Twitter at Meeting

We will be 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 ***#AAPTSM14***. Don't forget to include that hashtag in your tweets! Make sure to check social media 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

Contacts:

Meeting Registration Desk: 240-247-7001

AAPT Programs & Conferences Dept: 301-209-3340; programs@aapt.org

Tiffany Hayes, Director, Programs & Conferences

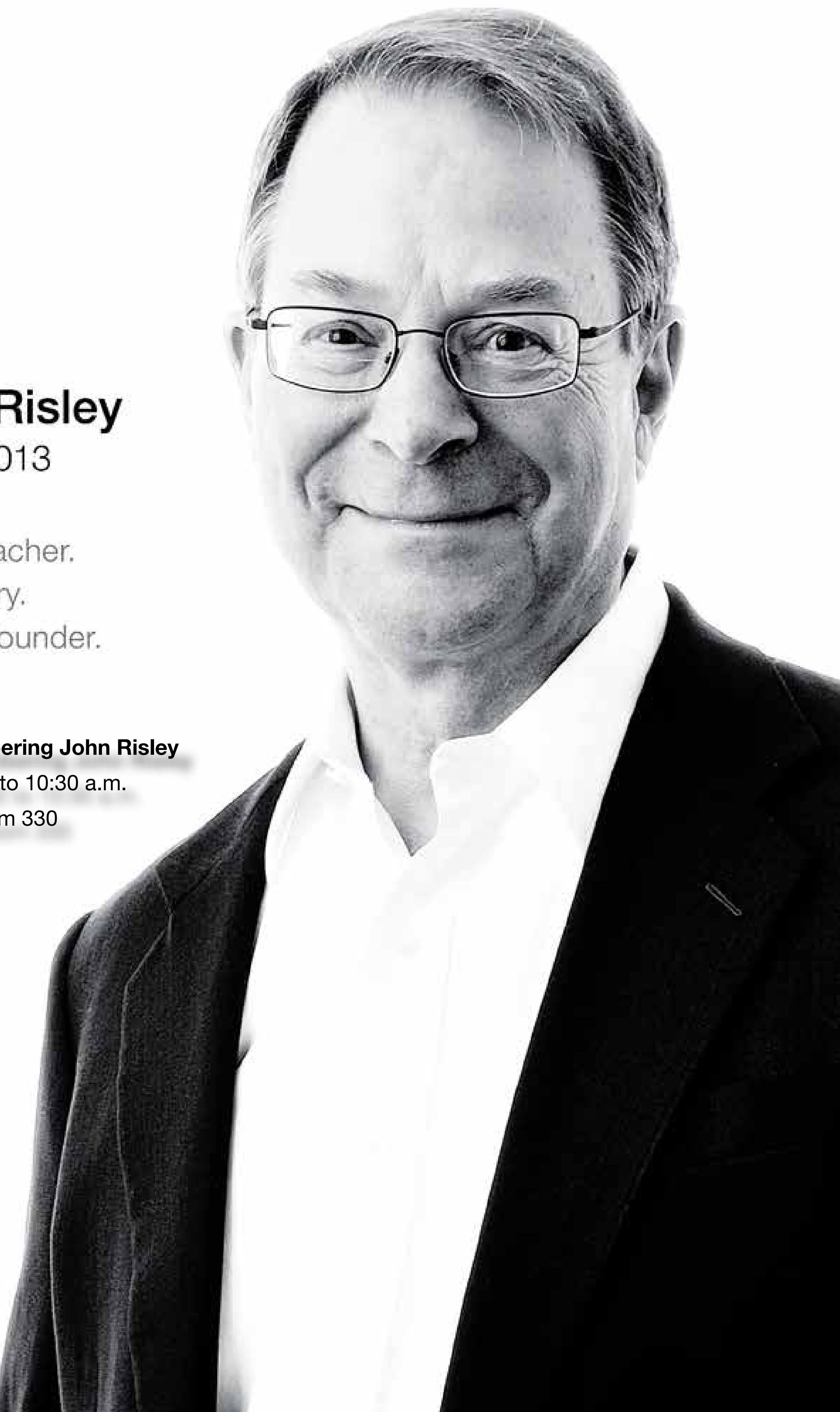
Cerena Cantrell, Associate Director, Programs & Conferences

Janet Lane, Programs Administrator

Pearl Watson, Meetings Logistics & Registration Coordinator

Wanyu Li, Summer Intern

American Association of Physics Teachers
One Physics Ellipse
College Park, MD USA 20740-3845
301-209-3340, fax: 301-209-0845
programs@aapt.org, www.aapt.org



Dr. John Risley

1942–2013

Physics teacher.
Visionary.
WebAssign founder.

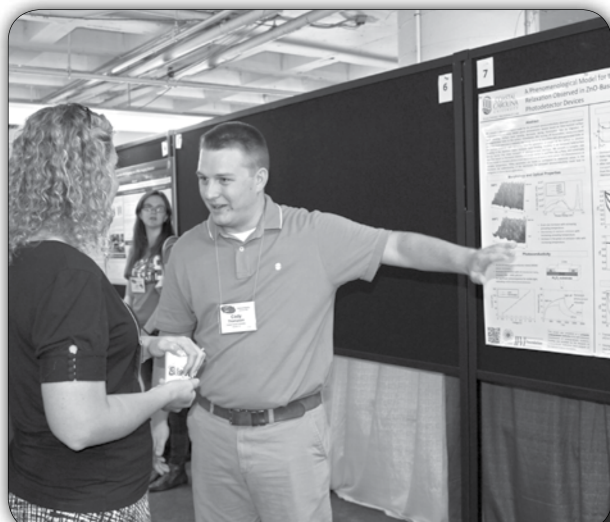
Session FA: Remembering John Risley
Wednesday, 8:30 to 10:30 a.m.
STSS Room 330

WebAssign

First time at an AAPT meeting?

Welcome to the 2014 AAPT Summer Meeting in Minneapolis! 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 22 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' Gathering from 7–8:30 a.m. on Monday in Coffman Union – Mississippi. 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 morning. We will run along the river and see a lot of University of Minnesota sights.
- 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.



Conference bags generously donated by PASCO scientific!

Congratulations to PASCO for a 50-year commitment to science education!

PERIMETER PI INSTITUTE FOR THEORETICAL PHYSICS

EXPLORE CHANGING IDEAS ABOUT OUR **UNIVERSE** IN YOUR CLASSROOMS

Come visit us at **BOOTH #306** and attend our

Perimeter Workshops at AAPT

PRESENTERS Dr. Damian Pope & Kevin Donkers
FOCUS Senior Physics, AP Physics, IB Physics
LOCATION Science Teaching and Student Services Building (STSS) Room 131A

1 A NEW SPIN ON CLASSICAL PHYSICS

Monday, July 28th | 12:00pm – 1:00pm

Are you looking for new and innovative ways to spice up classical physics concepts and expose your students to hands-on, modern physics without taking up extra time? This session explores how your everyday classical physics lessons can easily be connected to interesting concepts in modern physics including relating dark matter to circular motion, nuclear physics using electric fields, and how to detect sub-atomic particles using conservation of momentum. All activities presented connect to the new NGSS Standards.

2 HANDS-ON WAVE-PARTICLE DUALITY

Monday, July 28th | 1:30pm – 2:30pm

The wave-particle duality is one of the deepest mysteries of quantum mechanics. Come explore hands-on activities that introduce students to this vitally important concept in the quantum world. Perimeter's *The Challenge of Quantum Reality* classroom resource is developed in collaboration with educators and PI researchers with connections to the new NGSS Standards.

3 BEYOND THE ATOM: REMODELLING PARTICLE PHYSICS

Tuesday, July 29th | 11:30am – 12:30pm

The discovery of the Higgs boson was one of the biggest physics announcements of our generation. Join us as we explore concepts of momentum, charge, and fields being applied to modern particle physics. Perimeter's *Beyond the Atom: Remodelling Particle Physics* classroom resource is developed in collaboration with educators and PI researchers with connections to the new NGSS Standards.

4 COSMIC MYSTERIES

Tuesday, July 29th | 1:00pm – 2:00pm

Join Perimeter's NEWEST workshop designed to help teachers and students unravel the mysteries of space and the universe. This session shares hands-on activities focused on the big bang theory, expanding universe, black holes, redshift, cosmic microwave background, and more. Perimeter's *Cosmic Mysteries* classroom resource is developed in collaboration with educators and PI researchers with connections to the new NGSS Standards.

Visit the PI STORE at
www.perimeterinstitute.ca/store
Save with Coupon Code **AAPT0714**

Minneapolis – A city of lakes!

Minneapolis is the largest city in Minnesota, and with its twin city St. Paul, the state's capital, the area makes up the 16th largest metro area in the nation. The Mississippi River is crucial to the area and the city borders both sides of the river. In the early years, St. Anthony Falls, formerly the highest waterfall on the river, was used for powering sawmills for the burgeoning lumber industry. By 1871, the west river bank had several new businesses including flour mills, woolen mills, paper mills, iron works, and a railroad machine shop. The city is known for its many lakes, Mississippi River, creeks and waterfalls, connecting to the Chain of Lakes and the Grand Rounds National Scenic Byway.

The name Minneapolis (Sioux word for water and Greek word for city) is attributed to the city's first school teacher, Charles Hoag. Dakota Sioux were the region's sole residents until French explorers arrived around 1680. Fort Snelling was built nearby in 1819 by the U.S. Army, and that spurred growth. A band of the Dakota, the Mdewakanton, were "persuaded" by the U.S. government to cede their land to settlers from the East beginning around 1837.

Minneapolis became a town in 1856 and was incorporated as a city in 1867, which was the year that rail service between Chicago and Minneapolis began. St. Anthony Falls spurred many flour mills around the turn of the century, including the father of modern milling. Cadwallader C. Washburn, founder of General Mills. His revolutionary milling technology included gradual reduction processing by steel and porcelain roller mills which could quickly produce pure white flour from grain. Charles A. Pillsbury was not far behind across the river and the flour production in the area became known as the best in the world. The millers worked with scientists at the University of Minnesota. By 1900, 14.1 percent of America's grain was milled in Minneapolis.

In 1934 a violent Teamsters strike led to laws protecting workers' rights. Minneapolis Mayor Hubert Humphrey, a union supporter and civil rights activist, helped the city set up fair-employment practices and in 1946 set up a human relations council that interceded on behalf of minorities.

Education

The largest institution of higher education is The University of Minnesota, home of the Golden Gophers. Also in the city are: Augsburg College, Minneapolis College of Art and Design, North Central University, Minneapolis Community and Technical College, Dunwoody College of Technology, Globe University/Minnesota School of Business, and Art Institutes International Minnesota. St. Mary's University of Minnesota has a Twin Cities campus for its graduate and professional programs. Capella University, Minnesota School of Professional Psychology, and Walden University are headquartered in Minneapolis.

Referenced: Wikipedia

Things to do in Minneapolis:

▶ **Mill City Museum:** Built from the ruins of the former largest flour mill, the museum is located on the river bank and details the history of the flour mill industry which helped make Minneapolis what it is today. (704 South 2nd St., Minneapolis; *www.millcitymuseum.org*)

▶ **The Science Museum of Minnesota:** Hands-on exhibits, larger-than-life Omnitheater films, and a world-class collection of fossils and artifacts. (120 W. Kellogg Blvd., St. Paul; *www.smm.org*)

▶ **Weisman Art Museum:** Located on the campus of the University of Minnesota, this museum features fine arts from the contemporary period. Open Tuesday–Friday, 10 a.m.–5 p.m., Wednesday, 10 a.m.–8 p.m., Saturday and Sunday, 11 a.m.–5 p.m. (333 East River Road, Minneapolis; *www.weisman.umn.edu*)

▶ **Minneapolis Institute of Arts:** Travel through 4000 years of world history as you view more than 80,000 works of sculpture, photography, paintings, drawings and prints. Open Tuesday–Saturday, 10 a.m.–5 p.m.; Sunday, 11 a.m.–5 p.m. (2400 3rd Ave. S, Minneapolis; *new.artsmia.org*)

▶ **The Bakken Museum:** Learning center that explores the history, impact, and applications of electricity and magnetism in the life sciences. Exhibits include: Ben Franklin's Electricity Party, Body Electric, and Mysteries of Magnetism. Open Tuesday–Saturday, 10 a.m.–5 p.m.; Thursdays til 8 p.m. (3537 Zenith Ave. S, Minneapolis; *www.thebakken.org*)

▶ **Nicollet Avenue:** South Minneapolis street referred to as "Eats Street" because of its large selection of ethnic restaurants.

▶ **Walker Art Center:** Internationally recognized as a leading arts venue, Walker Art Center presents contemporary visual arts and design exhibitions; dance, theater, and music performances; and film screenings. Open Tuesday–Sunday 11 a.m.–5 p.m. and open until 9 p.m. on Thursdays. (11750 Hennepin Ave., Minneapolis; *www.walkerart.org/*)

▶ **Minneapolis Lakes:** Five-lake chain in the city. Lake of the Isles at Franklin and Logan Ave. South is known for its scenic views, outdoor activities. Lake Harriet at W. 42nd St. and West Lake Pkwy. features bandshell on north side for free concerts, including Garrison Keillor and the Minnesota Orchestra. Flower garden, scenic trolley.

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 on the campus of University of Minnesota, including the Coffman Memorial Union, the STSS (Science Teaching & Student Services), the Tate Lab of Physics, Northrop Auditorium, or the Commons Hotel.

FRIDAY, July 25

7 a.m.–6 p.m.		PTRA Summer Institute	STSS 512A
7:30 a.m.–9:30 p.m.		Soudan/NOVA Trip	offsite
4–7 p.m.		**REGISTRATION**	Coffman Union ground floor

SATURDAY, July 26

7 a.m.–4 p.m.		**REGISTRATION**	Coffman Union ground floor
8 a.m.–12 p.m.	W01	Morning Tour of the Bakken Museum	offsite
8 a.m.–12 p.m.	W02	Integrating Direct-Measurement Videos into Physics Instruction	STSS 330
8 a.m.–12 p.m.	W03	Open-Source Electronics for Laboratory Physics	Tate 215
8 a.m.–12 p.m.	W04	FPGAs in the Lab	Tate 65
8 a.m.–12 p.m.	W06	Inquiring into Radioactivity for Radiation Literacy	STSS 512B
8 a.m.–12 p.m.	W08	Making Interactive Video Vignettes and Interactive Web Lectures	STSS 432A
8 a.m.–5 p.m.	W09	Physics of Energy	Tate 226
8 a.m.–5 p.m.	W10	AP Physics 1&2	STSS 432B
8 a.m.–5 p.m.	W11	Learning Physics While Practicing Science: Introduction to ISLE	STSS 420B
8 a.m.–5 p.m.	W12	PIRA Demonstration Workshop I	Tate 150
9 a.m.–12 p.m.	T01	Not Everyone Wants to go to Graduate School: How to be an Effective Mentor	STSS 117
12:30–4:30 p.m.		AAPT Executive Board Retreat	Commons Hotel - Think 4
1–3 p.m.	T02	GlowScript: An Easy-to-Use Programming Environment for 3D Browser Animations	STSS 312
1–5 p.m.	W13	Introductory Laboratories	Tate 130
1–5 p.m.	W14	Afternoon Tour of the Bakken Museum	offsite
1–5 p.m.	W15	Activity-based Physics for the Advanced H.S. Classroom	Tate 225
1–5 p.m.	W16	Tinkering and Explorations in Science–Integrating Sensors & Data Acq. with Arduino	Tate 140
1–5 p.m.	W18	Tips for Putting Fire into Your Teaching	STSS 131B
1–5 p.m.	W19	Skepticism in the Classroom	STSS 432A
1–5 p.m.	W20	Introductory Physics for Life Science–Curricular Materials and Activities	STSS 530B
6–7:30 p.m.		Nominating Committee (closed)	Commons Hotel - Think 3
6–9 p.m.		AAPT Executive Board	Commons Hotel - Think 4

SUNDAY, July 27

7 a.m.–4 p.m.		**REGISTRATION**	Coffman Union ground floor
8–10 a.m.		Publications Committee	Coffman Union 303
8–10:15 a.m.		Meetings Committee	Coffman Union Mississippi
8 a.m.–10 p.m.		High School Physics Photo Contest Viewing and Voting	Coffman Union ground floor
8 a.m.–12 p.m.	W22	Activities for Learning About Climate and Climate Change	STSS 432B
8 a.m.–12 p.m.	W23	Creating Interactive Web Simulations Using HTML5 and JavaScript	STSS 530A
8 a.m.–12 p.m.	W24	Integrating NGSS, Design, and Literacy	STSS 144
8 a.m.–12 p.m.	W25	What Every Physics Teacher Should Know About Cognitive Research	STSS 123
8 a.m.–12 p.m.	W26	Extreme Engineering for the H.S. Students and Teachers	STSS 432A
8 a.m.–12 p.m.	W27	Patterns Approach	STSS 530B
8 a.m.–12 p.m.	W28	Teaching Astronomy with Mobile Devices	STSS 330
8 a.m.–12 p.m.	W29	Demo Kit in a Box	STSS 312
8 a.m.–12 p.m.	W30	Interactive Engagement in the Upper Division: Methods and Materials from CU-Boulder	STSS 412
8 a.m.–12 p.m.	W31	Strengthening Mathematical Sensemaking in Physics	STSS 512B
8 a.m.–12 p.m.	W32	New RTP and ILD Tools and Curricula: Video Analysis, Clickers, and E&M Labs	Tate 225
8 a.m.–5 p.m.	W33	PIRA Demonstration Workshop II	Tate 150
8 a.m.–5 p.m.	W34	Research-based Alternatives to Traditional Physics Problems	STSS 117
10:30 a.m.–4 p.m.		AAPT Executive Board II	Commons Hotel - Think 4
1–5 p.m.	W35	Advanced Labs	Tate 65
1–5 p.m.	W36	Cosmology in the Classroom	STSS 530B
1–5 p.m.	W37	LEAP: Learner-Centered Environment for Algebra-based Physics	STSS 432A
1–5 p.m.	W38	Improving Assessment in Your Courses Using Tools from the PER User's Guide	STSS 432B
1–5 p.m.	W39	Strategies to Help Women Succeed in Physics-related Professions	STSS 121
1–5 p.m.	W40	Research-based Materials for a New Introductory Quantum Mechanics Curriculum	STSS 330
1–5 p.m.	W42	Using, Modifying, and Building Internet Problem-solving Coaches for Your Students	STSS 512B
1–5 p.m.	W43	Using the MIT MOOC to Teach You and Your Class Better	STSS 530A

1–5 p.m.	W44	SCALE-UP 1	STSS 312
1–5 p.m.	W45	Physics and Toys II: Energy, Momentum, Electricity, and Magnetism Scheduling	STSS 420B
1–5 p.m.	W46	Physics Union Mathematics: Bringing Science & Engineering Practices to Classroom	STSS 420A
5:30–6:30 p.m.		Programs Committee I	STSS 330
5:30–8 p.m.		Section Officers Exchange / Section Representatives	STSS 220
6–8 p.m.		High School Share-a-Thon	Tate Lab 133
6:30–8 p.m.		PIRA Committee	STSS 512A
6:30–8 p.m.		Committee on Teacher Preparation	STSS 420B
6:30–8 p.m.		Committee on Physics in Undergraduate Education	STSS 432B
6:30–8 p.m.		Committee on Women in Physics	STSS 432A
6:30–8 p.m.		Committee on the Interests of Senior Physicists	STSS 131B
7:30–9 p.m.		**Evening REGISTRATION**	Coffman Union ground floor
8–10 p.m.		Exhibit Hall Opening and Reception	Coffman Union Great Hall
8–10 p.m.		PIRA Resource Room	Coffman Great Hall Annex
8–10 p.m.		SPS Undergraduate Research and Outreach Poster Session	Coffman Union ground floor
8–10 p.m.		TYC Resource Room	Coffman Union ground floor

MONDAY, July 28

7–8:30 a.m.		First Timers' Gathering	Coffman Union Mississippi
7–8:30 a.m.		Committee on Diversity in Physics	STSS 420B
7–8:30 a.m.		Committee on Educational Technologies	STSS 432A
7–8:30 a.m.		Committee on Graduate Education in Physics	STSS 432B
7–8:30 a.m.		Committee on Science Education for the Public	STSS 131B
7 a.m.–5 p.m.		**REGISTRATION**	Coffman Union ground floor
7:30–8:30 a.m.		Retired Physicists' Breakfast	Commons Hotel - Think 4
8 a.m.–10 p.m.		H.S. Physics Photo Contest Viewing / Voting	Coffman Union ground floor
8:30–9:30 a.m.	AD	Physics in a Biological Context	STSS 412
8:30–9:40 a.m.	AF	Teacher Training and Enhancement	Tate Lab 131
8:30–9:50 a.m.	AA	High School Topics	STSS 220
8:30–9:50 a.m.	AI	Introductory Labs and Apparatus	Tate Lab 170
8:30–10 a.m.	AB	Historical Perspectives on Teaching Physics	STSS 330
8:30–10 a.m.	AC	Creating Research-like Experiences for All Students	STSS 114
8:30–10 a.m.	AE	PER in Upper Division Physics	STSS 230
8:30–10 a.m.	AG	The Impact of the GRE and Graduate Admissions on Diversity in Graduate School	Tate Lab 133
8:30–10 a.m.	AH	Getting Started in PER	Tate Lab 166
10–10:30 a.m.		Morning Break Exhibit Hall / Kindle Fire Drawing (10:15 a.m.)	Coffman Union Great Hall
10 a.m.–5 p.m.		**Exhibit Hall Open**	Coffman Union Great Hall
10 a.m.–5 p.m.		PIRA Resource Room	Coffman Great Hall Annex
10 a.m.–5 p.m.		TYC Resource Room	Coffman Union ground floor
10:30 a.m.–12 noon		**AAPT Teaching Awards / Distinguished Service Citations**	**Northrop Auditorium**
12–1 p.m.	**CW01**	PASCO Capstone: Simple and Powerful Data Analysis for Physics	STSS 131B
12–1 p.m.	**CW02**	Put Your Online Physics Lab Courses in Motion!: eScience Labs LLC	STSS 530A
12–1 p.m.	**CW05**	Perimeter Institute: A New Spin on Classical Physics	STSS 131A
12–1 p.m.	**CW13**	Pearson Education: Eugenia Etkina	STSS 210
12–1:30 p.m.		Early Career Speed Networking	Coffman Union President's
12–1:30 p.m.		High School Teachers' Day Luncheon	Coffman Union Mississippi
12–1:30 p.m.		Review Board	STSS 123
12–1:30 p.m.		Physics Bowl Advisory Committee	STSS 144
12–1:30 p.m.		Spouse/Guest: Mississippi Queen Paddle Boat Tour	offsite
12–1:30 p.m.	TOP02	Troubleshooting Apparatus Topical Discussion	STSS 420B
12–1:30 p.m.	TOP03	Physics and Society Topical Discussion	Tate Lab 210
12–1:30 p.m.	TOP04	PER Solo Faculty Topical Discussion	STSS 432A
1:30–2:30 p.m.	**CW06**	Perimeter Institute: Hands-on Wave-Particle Duality	STSS 131A
1:30–2:20 p.m.	BJ	Physics of Phun	STSS 114
1:30–2:40 p.m.	BD	Teaching Advanced/Honors Students	Tate Lab 131
1:30–2:50 p.m.	BC	Creating Research-like Experiences for All Students II	Tate Lab 170
1:30–3 p.m.	BE	PER in Upper Division Physics II	STSS 230
1:30–3 p.m.	BH	Preparing Physics Teachers to Teach in Diverse Environments	STSS 412
1:30–3 p.m.	TOP01	YouTube Share-a-thon	Tate Lab 210
1:30–3:10 p.m.	BB	PER: Exploring Problem Solving Approaches and Skills	STSS 220
1:30–3:20 p.m.	BF	Outreach: Fun Ways to Engage	Tate Lab 133
1:30–3:20 p.m.	BG	K-12 PER	Tate Lab 166
1:30–3:30 p.m.	BA	MOOCs and You	STSS 312
1:30–3:30 p.m.	BI	Panel–Two-Year College New Faculty Experience: Commencement Conference Update	STSS 330
2:30–3:20 p.m.	BK	Making Physics Phun	STSS 114

3–4 p.m.		Melba Phillips Toast: Meet the Authors of *Women in Physics*	Coffman Union Great Hall
3:30–4 p.m.		Afternoon Break in Exhibit Hall / AmEx Gift Card Drawing (3:45 p.m.)	Coffman Union Great Hall
4–4:40 p.m.	CJ	Using Games to Teach Physics	STSS 114
4–5:30 p.m.	TOP05	iOS and Android App Show	STSS 131B
4–5:30 p.m.	CE	Art and Science of Teaching	STSS 230
4–5:30 p.m.	CF	Physics and Society: Current Topics in Energy	Tate Lab 166
4–5:30 p.m.	CD	Perspectives in Particle Physics	STSS 312
4–5:40 p.m.	CI	Upper Division and Graduate Courses and Labs	Tate Lab 131
4–5:50 p.m.	CG	Translating Teachers' Research Experience into Classroom Practice	STSS 412
4–6 p.m.	CA	Panel – Educational Technology Highlights from MPTL	STSS 330
4–6 p.m.	CB	Incorporating Metacognition in Physics Instruction and Assessing Outcomes	STSS 220
4–6 p.m.	CC	Panel – The Work of the Undergraduate Curriculum Task Force	Tate Lab 133
4–6 p.m.	CH	Panel – Confessions of a First Year Faculty Member	Tate Lab 170
4:50–6 p.m.	CK	Interactive Lecture Demonstrations–What's New? ILDs Using Clickers & Video Analysis	STSS 114
6–7 p.m.	TOP06	Graduate Student Topical Discussion	Tate Lab 166
6–7:30 p.m.		SPS Undergraduate Awards Reception	Coffman Union Mississippi
6–7:30 p.m.		Committee on Apparatus	STSS 420B
6–7:30 p.m.		Committee on Physics in High Schools	STSS 312
6–7:30 p.m.		Committee on International Physics Education	STSS 432A
6–7:30 p.m.		Committee on Professional Concerns	STSS 432B
6–7:30 p.m.		Committee on Space Science and Astronomy	STSS 131B
7:30–8:30 p.m.		**Plenary: The Uncanny Physics of Superhero Comic Books (Book Signing)**	**Northrop Auditorium**
8:30–10 p.m.		PTRA Advisory Committee	Tate Lab 157
8:30–10 p.m.		Poster Session I	Coffman Union ground floor
8:30–9:30 p.m.		AAPT Fellows Reception	Northrop Auditorium
8:30–10 p.m.		ALphA Committee	Coffman Union 323
TUESDAY, July 29			
6:30–8 a.m.		AAPT Fun Run/Walk	offsite
7–8 a.m.		Committee on Governance Structure (COGS)	STSS 420B
7–8 a.m.		Frederick & Florence M. Bauder Endowment Committee/Venture Committee	STSS 119
7–8:30 a.m.		Two-Year College Breakfast	Coffman Union President's
7 a.m.–4:30 p.m.		**REGISTRATION**	Coffman Union ground floor
8–9:10 a.m.	DH	Electronic Lab Notebooks	Tate Lab 133
8–9:10 a.m.	DJ	Reform Dissemination: Successful Examples	Tate Lab 131
8–9:30 a.m.	DF	Stories, Replicas, & Kits	Tate Lab 170
8–9:50 a.m.	DG	PER: Evaluating Instructional Strategies I	STSS 220
8–10 a.m.	DA	Teaching the "Women in Physics" Course	STSS 230
8–10 a.m.	DB	Sustainability of Physics Teacher Prep Programs	STSS 114
8–10 a.m.	DC	Broader Perspectives on Research in Learning Quantum Mechanics	STSS 312
8–10 a.m.	DD	Assessment Issues in Undergraduate Instruction	STSS 330
8–10 a.m.	DE	Developing Experimental Skills in the Introductory Lab	STSS 412
8 a.m.–4 p.m.		H.S. Physics Photo Contest Viewing and Voting	Coffman Union ground floor
9–10 a.m.		Exhibitors' Breakfast	Coffman Union President's
9:20–10 a.m.	DI	Arduinos Micro-Controllers and Underwater ROVs	Tate Lab 133
9:20–10 a.m.	DK	If They Build It, They Will Learn	Tate Lab 131
10–10:30 a.m.		Morning Break in Exhibit Hall / AmEx Gift Card drawing (10:15 a.m.)	Coffman Union Great Hall
10 a.m.–4 p.m.		**Exhibit Hall Open**	Coffman Union Great Hall
10 a.m.–4 p.m.		PIRA Resource Room	Coffman Great Hall Annex
10 a.m.–4 p.m.		TYC Resource Room	Coffman Union ground floor
10:30–11:30 a.m.		**Klopsteg Memorial Lecture Award: Donald W. Olson**	**Northrop Auditorium**
11:30 a.m.–12:30 p.m.	**CW04**	PASCO Capstone: Simple and Powerful Data Analysis for Physics	STSS 131B
11:30 a.m.–12:30 p.m.	**CW03**	Increasing Student Success and Retention Using Open Education Resources: OpenStax	STSS 432A
11:30 a.m.–12:30 p.m.	**CW07**	Perimeter Institute: Beyond the Atom: Remodelling Particle Physics	STSS 131A
11:30 a.m.–12:30 p.m.	**CW09**	Vernier Software: Data Collection Tools for Physics	Coffman Union President's
11:30 a.m.–12:30 p.m.	**CW12**	How WebAssign's Online Homework Can Help You Achieve Your Pedagogical Goals	STSS 119
11:30 a.m.–12:30 p.m.	**CW11**	Making Holograms for Cool Physics Impact: Liti Holographics	STSS 530A
11:30 a.m.–1 p.m.		Committee on Laboratories	STSS 420B
11:30 a.m.–1 p.m.		Committee on History & Philosophy in Physics	STSS 512B
11:30 a.m.–1 p.m.		Committee on Physics in Pre-High School Education	STSS 432B
11:30 a.m.–1 p.m.		Committee on Research in Physics Education (RiPE)	Tate Lab 133
11:30 a.m.–1 p.m.		Committee on Physics in Two-Year Colleges	STSS 512A
12–1 p.m.		The Easy JavaScript Simulations Platform: A Reader for Android and iOS Tablets	STSS 420A
12–1 p.m.	**CW10**	Expert TA and OpenStax College Workshop	Coffman Union Mississippi
12–1 p.m.		*TPT* Editorial Luncheon (closed)	Coffman Union 323

1–2 p.m.	**CW08**	Perimeter Institute: Cosmic Mysteries Workshop	STSS 131A
1–2 p.m.	EI	Best Practices in Educational Technology I	STSS 230
1–2:20 p.m.	EB	Physics in a Biological Context II	STSS 312
1–2:30 p.m.	EF	The Role and Implementation of Upper-level E&M	Tate Lab 131
1–2:40 p.m.	EC	Teachers in Residence	STSS 412
1–2:40 p.m.	EH	Histories Useful for Teaching Physics	STSS 114
1–3 p.m.	EA	Bridging Research and Teaching through Computation	STSS 330
1–3 p.m.	ED	PER: Diverse Investigations	STSS 220
1–3 p.m.	EE	Same Physics Other Ways	Tate Lab 170
1–3 p.m.	EG	What Can PER Contribute to the Design of High Quality Distance Education?	Tate Lab 166
1:15–2:45 p.m.		Advanced Labs Tour – Bethel University	offsite
2–3 p.m.	EJ	Technologies	STSS 230
3–3:30 p.m.		Afternoon Break in Exhibit Hall / iPad Mini Drawing (3:15 p.m.)	Coffman Union Great Hall
3:30–5 p.m.		**APS Plenary, Sponsored by the Division of Particles and Fields**	**Northrop Auditorium**
5–6:30 p.m.		Poster Session II	Coffman Union ground floor
6:30–7:30 p.m.		Trolley Tour of Minneapolis	offsite
8–9 p.m.		Demo Show	Willey Hall
10 p.m.–1 a.m.		Pub Crawl (starts in Lobby of Marriott)	offsite
WEDNESDAY, July 30			
7–8:30 a.m.		Awards Committee (closed)	Commons Hotel - Think 4
7–8:30 a.m.		Programs II Committee	Commons Hotel - Pathways
8 a.m.–3 p.m.		**REGISTRATION**	Coffman Union ground floor
8:30–9:20 a.m.	FJ	Strategies for Teachers and Professors to Support Female Students	STSS 312
8:30–9:40 a.m.	FH	Mentoring in the Physics Community	STSS 220
8:30–9:50 a.m.	FC	Reform Dissemination: Successful Examples II	Tate Lab 170
8:30–10 a.m.	FD	Introductory Courses	Tate Lab 131
8:30–10:10 a.m.	FF	PER: Modeling Student Engagement	Tate Lab 166
8:30–10:20 a.m.	FE	Magnetism and Thermal Labs, Beyond First Year	Tate Lab 133
8:30–10:30 a.m.	FA	Remembering John Risley	STSS 330
8:30–10:30 a.m.	FB	Seeking Employment in Academia	STSS 412
8:30–10:30 a.m.	FG	Broader Perspectives: Research-based Strategies to Improve Teaching and Learning	STSS 114
9:20–10:10 a.m.	FK	Additional Strategies to Support Female Students	STSS 312
9:50–10:30 a.m.	FI	Teacher Communities: Supporting Beginning Teachers of Physics	STSS 220
10:30–11:30 a.m.		**Robert A. Millikan Medal: Eugenia Etkina**	**Northrop Auditorium**
11:30 a.m.–12:30 p.m.	TOP07	PERTG Town Hall	Tate Lab 166
11:30 a.m.–12:30 p.m.	TOP11	The 5th International Conference on Women in Physics	STSS 330
11:30 a.m.–1 p.m.		Membership and Benefits Committee	Tate Lab 157
11:30 a.m.–1 p.m.		SI Units and Metric Education Committee	Tate Lab 143
11:30 a.m.–1 p.m.	TOP08	Web Resources for Teaching Astronomy	STSS 114
11:30 a.m.–1 p.m.	TOP09	Physics on the Road: Developing a Manual	STSS 230
1–2:30 p.m.		Post-deadline Poster Session	Coffman Union ground floor
1–2:10 p.m.	GD	Bridging Engineering, Math, and Physics	Tate Lab 170
1–2:20 p.m.	GH	Post-deadline Session II	Tate Lab 166
1–2:30 p.m.	GI	Post-deadline Session III	STSS 114
1–2:30 p.m.	GB	A Potpourri of Physics and Physics Teaching Ideas	STSS 330
1–2:40 p.m.	GF	Introductory Courses II	STSS 312
1–2:40 p.m.	GG	Post-deadline Session I	Tate Lab 133
1–2:40 p.m.	GE	PER: Evaluating Instructional Strategies II	Tate Lab 131
1–3 p.m.	GA	PER: Examining Content Understanding and Reasoning	STSS 220
1–3 p.m.	GC	Best Practices in Educational Technology II	STSS 412
3–3:30 p.m.		Great Book Give Away	Coffman Union ground floor
3–4:30 p.m.		Nominating Committee II (closed)	Commons Hotel - Think 1
3–4:30 p.m.		PERC Bridging Session	Northrop Auditorium
3–5:30 p.m.		AAPT Executive Board III	Commons Hotel - Think 4
3:30–5:30 p.m.		Zooniverse in the Classroom	STSS 131B
3:30–8:30 p.m.		Mall of America Trip	offsite
5–8:30 p.m.		PERC Banquet and Poster Reception	Commons Hotel
THURSDAY, July 31			
8:30 a.m.–4:15 p.m.		PER Conference	Commons Hotel

Special Events at AAPT Summer Meeting

Friday, July 25

▶ **Soudan/NOVA Trip**
7:30 a.m. to 9:30 p.m. offsite

Visit the two largest neutrino detectors and dark matter experiment in North America. These three important physics experiments are just a bus ride away from the campus of the University of Minnesota. Meet in Coffman Union near Registration. *Ticket required.*

Sunday, July 27

▶ **Grand Opening of Exhibit Hall and Opening Reception**
8–10 p.m. Sunday Coffman Union Great Hall

Monday, July 28

▶ **First Timers' Gathering**
7–8:30 a.m. Monday
Coffman Union Mississippi

Are you new to an AAPT National Meeting? If so, this is the best time to learn about AAPT and the Summer Meeting, as well as meet fellow attendees. AAPT leadership will be represented to discuss ways to get more involved with AAPT. You are also welcome to participate in any of AAPT's Area Committee meetings.

▶ **Retired Physicists' Breakfast**
7:30–8:30 a.m. Monday
Commons Hotel

Exchange ideas with our long-served and deserving supporters of AAPT. *Ticket required.*

▶ **Early Career Professionals Speed Networking Event**
12–1:30 p.m. Monday
Coffman Union President's Room

Speed-networking provides the opportunity to discuss career goals and challenges with a new contact for five minutes, exchange information, and then move on to the next person.

▶ **Spouse/Guest Mississippi Queen Paddle Boat Tour**
12–1:30 p.m. Monday offsite

Take a narrated sightseeing cruise on the historic Mississippi Queen paddle boat, a modern day replica of the grand riverboats that used to ply the Mississippi River. Meet in Coffman Union near Registration. *Ticket required.*

▶ **H.S. Physics Teachers Day Luncheon**
12–1:30 p.m. Monday
Coffman Union Mississippi

Join this special luncheon for H.S. teachers attending the conference for the first time. Open to anyone wishing to attend, but register early. Sponsored by i>clicker. *Ticket required.*

▶ **Exhibit Hall Kindle Fire Drawing**
– 10:15 a.m. Monday

▶ **Exhibit Hall $100 AmEX Gift Card Drawing**
– 3:45 p.m. Monday

Tickets $1 apiece, buy at Registration. Must be present to win!

▶ **Melba Phillips Toast**
3–4 p.m. Monday
Coffman Union Great Hall AAPT Booth

Tuesday, July 29

▶ **Two-Year College Breakfast**
7–8:30 a.m. Tuesday
Coffman Union President's Room

Two-Year College staff begin their day by breaking bread and sharing ideas. *Ticket required*

▶ **AAPT Fun Run / Walk**
6:30–8 a.m. Tuesday

Come enjoy the 7th annual AAPT Fun Run/ Walk! The event winds through the scenic UM East and West Bank campuses highlighting great views of the Mississippi River and historic buildings. Meet in Coffman Union near Registration. *Fee*

▶ **Exhibit Hall $100 AmEx Card Drawing**
– 10:15 a.m. Tuesday

▶ **Exhibit Hall IPad Mini Drawing**
– 3:15 p.m. Tuesday

Tickets $1; buy at Registration. Must be present to win!

▶ **Advanced Labs Tour – Bethel Univ.**
1:15–2:45 p.m. Tuesday

Tour will be a short van ride to Bethel University to see the physics department's advanced labs and undergraduate research. Pick up at 1:15 outside STSS Building.

▶ **Trolley Tour of Minneapolis**
6:30–7:30 p.m. Tuesday

You will experience a sampling of what makes Minneapolis fantastic! Your tour guide will provide commentary on downtown Minneapolis and surrounding areas. Meet in Coffman Union near Registration. *Ticket Required.*

▶ **Demo Show**
8–9 p.m. Tuesday
Willey Hall

▶ **Pub Crawl**
10 p.m.–1 a.m.
(Starts in Marriott lobby)

Wednesday, July 30

▶ **Great Book Giveaway**
3–3:30 p.m. Wednesday
Coffman Union

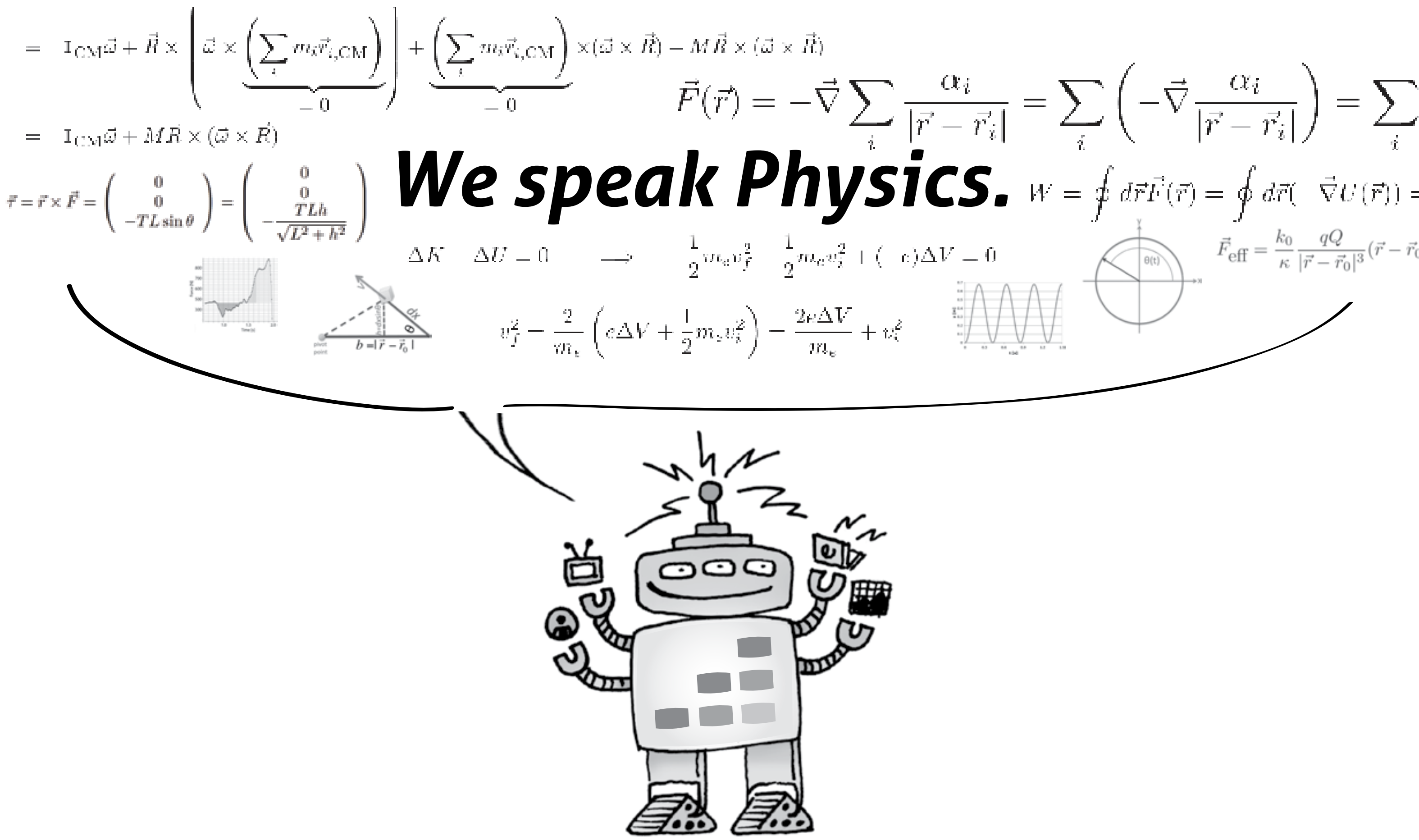
Get your raffle ticket from the AAPT booth (Sun–Tuesday) and attend this popular event to claim your book.

▶ **Zooniverse in the Classroom**
3:30–5:30 p.m. STSS 131B Wednesday

Over a million people have contributed to scientific research through the Zooniverse.org projects. The result is an entire suite of new web-based tools designed to assist citizen scientists in exploring vast quantities of astronomical data on their own.

▶ **Mall of America Trip**
3:30–8 p.m. Wednesday

The Mall of America is a place not to be missed! Over 520 stores and 50 restaurants with no tax on clothing and shoes. Meet in Coffman Union near Registration. *Ticket required*


We speak Physics.

Eugenia Etkina
Rutgers University
Professor of Physics
New Brunswick, NJ

Students of Physics: Listeners, Observers, or Collaborative Participants?

Wednesday, July 30

10:30–11:30 a.m.

Northrop Auditorium

Robert A. Millikan Medal

The **Robert A. Millikan Medal** for 2014 is presented to **Eugenia Etkina** for her notable and creative contributions to the teaching of physics. Etkina started her teaching career as a high school physics teacher in Moscow, Russia, where she taught for 13 years before coming to the U.S. In 1995-1997 she taught physics courses for at-risk students at Rutgers University. In 1997 she received her PhD in physics education from Moscow State Pedagogical University and was appointed an assistant professor at the Rutgers University Graduate School of Education. She became an associate professor in 2003 and a full professor in 2010 and served as the chair of the Department of Learning and Teaching from 2011 to 2014.

Since 2003 she has been running one of the largest programs in physics teacher preparation in the United States. Professional learning community of the program graduates now has over 60 physics teachers. Her pivotal role in sustaining and expanding this community is evidenced by the moniker that her New Jersey physics teachers use for themselves. Etkina is involved in reforms in undergraduate physics courses and in the professional development programs for in-service middle school science and high school physics teachers. She is a co-creator of the Investigative Science Learning environment (ISLE)—an approach to teaching and learning physics that helps students learn physics by engaging in activities that mirror the practice of physics. She is also a co-author of a newly published ISLE-based textbook College Physics and a companion Active Learning Guide. Together with her colleagues and students (now in-service teachers) she developed the Physics Union Mathematics (PUM) curriculum that is used in middle and high schools to help students learn physics through ISLE. An AAPT member since 1997, Etkina has 32 years of experience in physics and astronomy instruction at middle school, high school, and university levels. She has served AAPT on the Focus Group on the Draft Framework and on the 2013 AAPT Sponsored Discussion Group Response to Achieve on the Next Generation Science Standards Second Draft.

In addition to the AAPT Distinguished Service Citation that she received in 2012, Etkina has been recognized with the 2012 New Jersey Distinguished Faculty Showcase of Exemplary Practices Award, 2011 Rutgers University Graduate School of Education Alumni Association Outstanding Faculty Teaching Award, 2010 Rutgers University Warren I Susman Award for Excellent Teaching, and the 2007 Rutgers University Graduate School of Education Alumni Association Outstanding Faculty Research Award.

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.

Donald W. Olson
Texas State University
Professor of Physics
San Marcos, TX

Celestial Sleuth: Using Physics and Astronomy to Solve Mysteries in Art, History, and Literature

Tuesday, July 29

10:30–11:30 a.m.

Northrop Auditorium

Klopsteg Memorial Lecture Award

The **Klopsteg Memorial Lecture Award** for 2014 is presented to **Donald W. Olson,** PhD, Professor of Physics at Texas State University, in recognition of his outstanding communication of the excitement of contemporary physics to the general public.

Don Olson is nationally known for his ability to apply physics to solve mysteries in art, history, and literature - and to communicate the results to the public in a coherent, exciting way. His work has been published in more than thirty articles in *Sky & Telescope* magazine and has been featured in the *Smithsonian Magazine*, *Scientific American,* and a host of major newspapers. Olson's recent book, *Celestial Sleuth* (Springer, 2014), collects his research in chapters devoted to night sky paintings by Vincent van Gogh, Edward Munch, Claude Monet, and J. M. W. Turner, moonrise photographs by Ansel Adams, events from military history ranging from the Battle of Marathon to moonlight and tides during World War II, and references to celestial phenomena by Chaucer, Shakespeare, Mary Shelley, Walt Whitman, and James Joyce.

Olson earned his BS in physics from Michigan State University, receiving upon graduation the Thomas H. Osgood Undergraduate Physics Award—an award named after the professor who was an early editor of the *American Journal of Physics* and the inspirational teacher in the first physics courses that Olson took at MSU. After earning his PhD in physics from the University of California-Berkeley, Olson studied galaxies and cosmology for four years at Cornell University and two years at the University of Texas at Austin, and he then began teaching at Texas State University in 1981. He has received many teaching awards during his career, including the 2011 Presidential Award for Excellence in Teaching, Texas State's top teaching award.

Olson has been a valuable participant at Texas Section AAPT/APS meetings for many years. He has twice given plenary talks on the use of astronomy and physics to solve mysteries in historical events and in topics from art and literature.

Regarding his selection as 2014 Klopsteg Award recipient, Olson said, "I am deeply honored to receive this recognition, especially because the award commemorates Paul Klopsteg, who dedicated so much of his life to physics education."

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 Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching

The 2014 **David Halliday and Robert Resnick Award** for Excellence in Undergraduate Physics Teaching is presented to **Ruth Chabay and Bruce Sherwood,** in recognition of their contributions to undergraduate physics teaching and their extraordinary accomplishments in communicating the excitement of physics to students. John Wiley & Sons is the principal source of funding for this award. Chabay earned a PhD in physical chemistry from the University of Illinois at Urbana-Champaign. She is Professor Emerita in the Department of Physics at North Carolina State University and recently was Weston Visiting Professor, Department of Science Teaching, at the Weizmann Institute of Science in Rehovot, Israel. She has also taught at the University of Illinois at Urbana-Champaign and Carnegie Mellon University. She is a Fellow of the American Physical Society.

Sherwood's PhD is in experimental particle physics from the University of Chicago. He is Professor Emeritus in the Department of Physics at North Carolina State University. He has also taught at Caltech, the University of Illinois at Urbana-Champaign, and Carnegie Mellon University. He is a Fellow of the American Physical Society.

Both Chabay and Sherwood have made great contributions to the modernization of the introductory, calculus-based Physics curriculum by authoring the *Matter & Interactions* textbook published by John Wiley & Sons, which integrates contemporary and classical physics by making macro-micro connections and emphasizing fundamental principles. They have played a major role in developing the VPython interactive 3D programming environment and integrating computational modeling into the introductory physics curriculum. Their goal has been to help students acquire the conceptual and computational skills to be able to apply fundamental physical principles to complex real-world systems.

Regarding their selection for this award they noted, "It's an honor to receive this award from AAPT, a community in which so many people think so deeply about teaching and learning physics. We especially value this community's willingness to take seriously nontraditional ideas about introductory physics, such as our conviction that introductory physics doesn't have to be about inclined planes, and that computational modeling can enable students to analyze complex systems, even at the introductory level."

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.

Ruth Chabay

Bruce Sherwood

Inviting Students Into the 21st Century

Monday, July 28

10:30 a.m.–12 p.m.

Northrop Auditorium

Paul W. Zitzewitz Award for Excellence in Pre-College Physics Teaching

The **Paul W. Zitzewitz Excellence in Pre-College Physics Teaching Award** for 2014 is presented to **Bradford K. Hill** in recognition of his career-long concern for and attention to quality education at the pre-college level. A high school physics teacher from Beaverton, OR, Hill earned his BS in Physics at the University of Minnesota. His MS in Physics was earned at the University of Maryland and his MA in Science Education at the University of California, Berkeley. Hill began teaching physics at Montgomery College in 2002 in Montgomery County, MD. He moved to Oregon in 2005 and began teaching physics at the high school level. He has been at Southridge High School since 2006, where he also now facilitates a district-wide collaboration of physics teachers.

Hill was a Knowles Science Teaching Mentor from 2009-2011. He was selected to help draft, align, create and test rubrics for the new Oregon state science Standards in 2009 and currently is on the Oregon Science Content Panel as Oregon considers adopting the Next Generation of Science Standards.

He received the 2013 Outstanding Classroom Science Teacher Award from the Oregon Science Teachers Association. From 2003 to 2008 he was a Knowles Science Teaching Fellow, and from 2012 – 2014 he performed original research in the Physics Department at Portland State University on characterizing dark current in Charged-Coupled Devices, under a Partners in Science Grant from the M. J. Murdock Charitable Trust.

Bradford develops, tests, and openly shares a curriculum he calls the Patterns Approach which meets the high standards of the NGSS. This approach introduces students to the power of recognizing patterns to make sense of novel situations from the very beginning of the course and engages them in high level inquiry and problem solving, He was so successful using this approach with ninth grade students, that it was adopted district wide. He has been sharing his work through local, state, and national conferences, publishing in the March 2013 issue of The Science Teacher, and providing extensive, ongoing professional development for teachers in his district and nationwide. He continues to study the impacts of this approach while also collaborating with other teachers across the country to further develop curriculum units for AP Physics, IB Physics, Project Based programs, and Chemistry.

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.

Bradford Hill
Southridge High School
Beaverton, OR

Citizen Science: Harnessing Physics to Advance Science and Mathematical Literacy

Monday, July 28

10:30 a.m. –12 p.m.

Northrop Auditorium

2014 Homer L. Dodge Citations for Distinguished Service to AAPT

Monday, July 28, 10:30 a.m.–12 p.m. • Northrop Auditorium

Paul J. (Joe) Heafner

Joe Heafner
Catawba Valley Community College

Paul J. (Joe) Heafner is Instructor of Astronomy and Physics at Catawba Valley Community College, Hickory, NC. He earned his Master of Science degree in physics at the University of North Carolina at Greensboro and his BA in astronomy at the University of North Carolina at Chapel Hill.

An AAPT member since 2000, Heafner has been active in the North Carolina Section, and has served on the AAPT Committee on Space Science and Astronomy, chairing the committee in 2013. He served on the Programs Committee in 2013 and is an active member of the Committee on Physics in Two-year Colleges.

Heafner has volunteered to serve on the Social Media Engagement Team helping to tweet information about AAPT's recent meetings as well as presenting workshops and papers at numerous AAPT and NCS-AAPT conferences.

Dyan Jones

Dyan Jones
Mercyhurst University

Dyan Jones, Assistant Professor of Physics at Mercyhurst University, Erie, PA, has been an active member of AAPT for nearly a decade. She did her undergraduate work at Edinboro University of PA, which is where she attended her first AAPT regional meeting. She graduated from Edinboro with a bachelors in theoretical physics in 1999. Following graduation she started her graduate studies at Miami University, working with Dr. Perry Rice on theoretical cavity QED. Jones received her MS in Physics in 2005.

While she loved theoretical quantum physics, she preferred being in the classroom and went on to doctoral studies at Kansas State University under the advisement of Dr. Dean Zollman in the physics education research group. She received her PhD in 2009. Jones has served as a member, Vice Chair, and Chair of the AAPT Committee on Professional Concerns, as a member and Chair of the Nominating Committee, and as a Committee Member of the Committee on Physics in Undergraduate Education. She serves as a member of the AAPT Membership & Benefits Advisory Committee and is active in the Western Pennsylvania Section as the Section Representative.

Martha Lietz

Martha Lietz
Niles West High School

Matha Lietz, a National Board Certified Teacher (Adolescents and Young Adults: Science-Physics) has her MS in Physics from Carnegie Mellon University. She teaches science at Niles West High School in Skokie, IL, and serves as an AP Consultant for the College Board and Educational Testing Service.

A member of AAPT since 1989, Lietz has served on the Committee of Computers in Physics Education, the Committee on Educational Technologies, the Committee on Physics in High Schools, and as a member of the Editorial Board for The Physics Teacher. She has also served as President and Section Representative for the Chicago Section. Lietz has presented workshops at AAPT national meetings, local section meetings, through the PTRA program and for the College Board. She has presented numerous papers and published articles in *The Physics Teacher.*

Evelyn Restivo

Evelyn Restivo
Maypearl, TX

Evelyn Restivo has been an active member of AAPT since 1985 serving as a role model for pre-service and inservice teachers through many different venues. She teaches students at all levels from high school through college in both chemistry and physics. She has worked tirelessly for PTRA, TSAAPT, and AAPT through countless workshops as both a leader and a co-presenter. Her career as a science teacher started in 1969, following her graduation from Central State College, Edmond, OK, with BSE in Natural Science. She has taught Biology, Chemistry, Geology, and Physics in Oklahoma, Tennessee, Georgia, and Texas. She continued her education, earning her MEd in 2001 at Texas A&M University, College Station, Texas.

A dedicated contributor to physics teaching in Texas for decades, she has served the Texas Section as President and as the TSAAPT liaison to Science Teachers Association of Texas. She has presented the Physics strand annually at the Conference for the Advancement of Science Teaching, a gathering of several thousand science teachers in Texas. She has also been a major contributor to Quarknet. In 2012, Restivo was the recipient of the Texas Section of the American Association of Physics Teachers Katherine Mays Award for Outstanding Contributions to Physics Education.

Established in 1953 and renamed in recognition of AAPT founder Homer L. Dodge in 2012, the Homer L. Dodge Citation for Distinguished Service to AAPT is presented to members in recognition of their exceptional contributions to the association at the national, sectional, or local level.


The Expert TA is an online system that is designed to help students learn and educators assess student work.
Our software is able to grade like you would - it can identify detailed mistakes in students' work and can then provide feedback about these mistakes and deduct points for a true partial credit grade.
Request a live demonstration today and find out why so many are excited about Expert TA!
EXPERT
ta

Roger Rusack
University of Minnsota

Lucy Fortson
University of Minnesota

Dan Cronin-Hennessy
University of Minnesota

APS Plenary, Sponsored by the Division of Particles and Fields

Tuesday, July 29, 3:30–5 p.m. • Northrop Auditorium

1. Physics at the CERN Large Hadron Collider, the Past, the Present and the Future

Roger Rusack, School of Physics and Astronomy, University of Minnesota

Roger Rusack has been a member of the faculty of the University of Minnesota since 1993. In his career he has worked on many of the experiments that have defined the Standard Model of particle physics, co-authoring more than 300 papers on the internal nature of hadrons and observations of the Higgs and the tau-neutrino. As a member of the CERN CMS collaboration, he was a major contributor to the 90-ton crystal detector that was used to measure photons that was one of the major signatures of the production of the Higgs boson.

2. Explorations in the Cosmic Frontier: Shedding Light on the Dark?

Lucy Fortson, School of Physics and Astronomy, University of Minnesota

Lucy Fortson is associate head of school and associate professor of physics in the School of Physics and Astronomy at the University of Minnesota. A member of the VERITAS and CTA very-high-energy gamma-ray astronomy collaborations, Dr. Fortson studies Active Galactic Nuclei (AGN) using multi-wavelength observations to determine the source of gamma-ray emission from AGN and the evolution of the AGN host galaxies. Dr. Fortson is also deeply committed to improving the science literacy of all Americans through her role on the Executive Committee of the Citizen Science Alliance and the Zooniverse project (www.zooniverse.org). With projects such as Galaxy Zoo, the Zooniverse provides opportunities for volunteer citizens to contribute to discovery research by using their pattern matching skills to perform simple data analysis tasks and to become more deeply engaged in the science research through social networking and simple data processing tools. Dr. Fortson was recently the vice president for research at the Adler Planetarium in Chicago where she held a joint research position at the University of Chicago. Dr. Fortson graduated with a BA in Physics and Astronomy from Smith College and received her PhD from UCLA in High Energy Physics. She has served on numerous local and national committees including the National Academy of Sciences Astronomy 2010 Decadel Survey, the Astrophysics Science Subcommittee and the Human Capital Committee of the NASA Advisory Council (NAC), the Mathematical and Physical Sciences Directorate Advisory Committee (MPSAC) for the National Science Foundation, and the Education and Public Outreach Review Committee for the National Optical Astronomy Observatory.

3. The Turn of the Screw: A Chilling Ghost Story of Nature's Most Unusual Fermion

Dan Cronin-Hennessy, School of Physics and Astronomy, University of Minnesota

Daniel Cronin-Hennessy is an associate professor of physics at the University of Minnesota. He previously worked at the Tevatron proton-antiproton collider where he studied the production of W bosons. Later he joined the CLEO collaboration where he improved measurements of the quark mixing parameters and pursued evidence for CP violation in the B meson sector. In 2004 he joined the faculty at the U of M. He is a 2006 recipient of a Sloan Fellowship. Recently Professor Hennessy served as co-chair of a national education and outreach study group as part of the DPF's long-range planning process. He runs two annual outreach activities, Mastersclass and QuarkNet, at the University of Minnesota which serves to engage high school students and teachers in frontier physics research. His current interest includes the study of the phenomena of neutrino oscillations. He is a member of the NuMI Off-Axis Electron Neutrino Experiment (NOvA) which has recently started acquiring data.

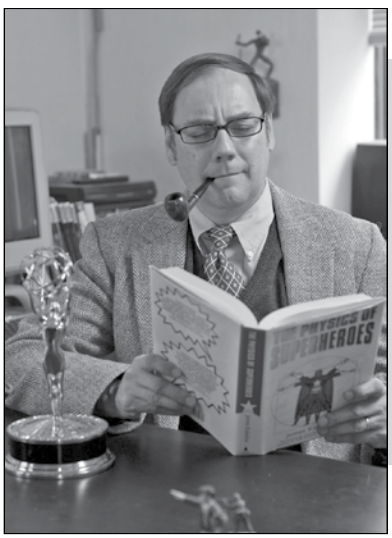
The Uncanny Physics of Superhero Comic Books

Monday, July 28, 7:30–8:30 p.m. • Northrop Auditorium

James Kakalios, School of Physics and Astronomy, The University of Minnesota

James Kakalios
University of Minnesota

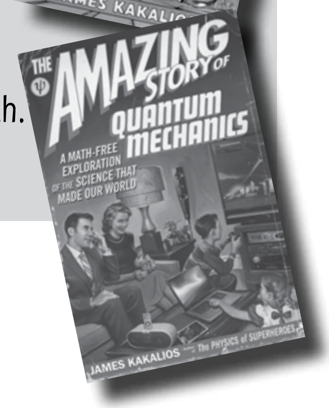
James Kakalios is the Taylor Distinguished Professor in the University of Minnesota's School of Physics and Astronomy. He received his PhD in Physics from the University of Chicago in 1985; worked as a post-doctoral research associate at the Xerox–Palo Alto Research Center; and then in 1988, having had enough of those California winters, joined the faculty of the School of Physics and Astronomy at the University of Minnesota. His popular science book *The Physics of Superheros* was published in 2005 in the U.S. and the U.K., and has been translated into German, Spanish, Korean, Chinese and Italian. *The Spectacular Second Edition* was published in November 2009, and his latest book *The Amazing Story of Quantum Mechanics* was released in October 2010. Through the National Academy of Sciences' program The Science and Entertainment Exchange, he has done volunteer consulting for Warner Bros. films "Watchmen" and "Green Lantern," and Sony's "The Amazing Spider-Man." A video he made for the University of Minnesota on The Science of Watchmen has been viewed over 1.8 million times, and in 2009 won an Upper Midwest regional EMMY award and was nominated for a national WEBBY award. His research interests include nanocrystalline and amorphous semiconductors, pattern formation in sandpiles and fluctuation phenomena in neurological systems. He has been reading comic books longer than he has been studying physics.

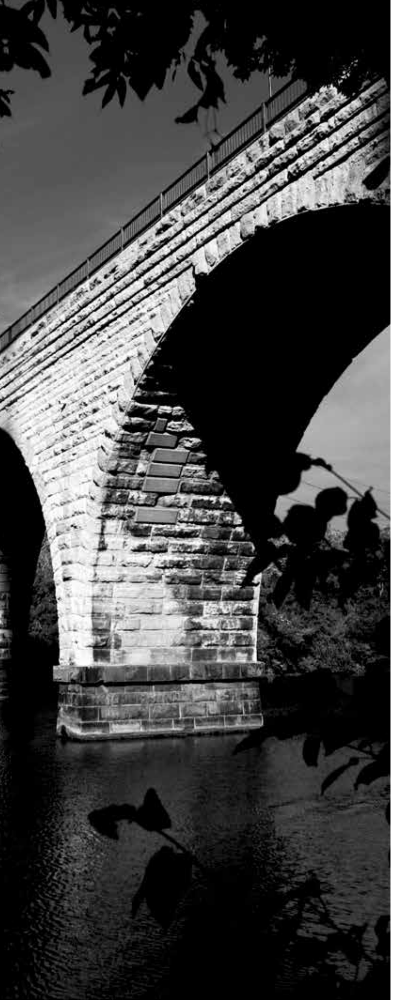


Meet the Author!

James Kakalios will be available right after the plenary for a book signing.

Purchase his books in the Exhibit Hall at the AAPT Booth.





Committee Meetings

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

Sunday, July 27

Publications Committee	8–10 a.m.	Coffman Union - 303
Meetings Committee	8–10:15 a.m.	Coffman Union - Mississippi
Executive Board II	10:30 a.m.–4 p.m.	Commons Hotel - Think 4
Programs Committee I	5:30–6:30 p.m.	STSS 330
Section Representatives	5:30–8 p.m.	STSS 220
High School Share-a-Thon*	6–8 p.m.	Tate Lab 133
PIRA Committee*	6:30–8 p.m.	STSS 512A
Committee on Teacher Preparation*	6:30–8 p.m.	STSS 420B
Committee on Physics in Undergrad. Ed.*	6:30–8 p.m.	STSS 432B
Committee on Women in Physics*	6:30–8 p.m.	STSS 432A
Committee on Interests of Senior Physicists*	6:30–8 p.m.	STSS 131B

Monday, July 28

Committee on Diversity in Physics*	7–8:30 a.m.	STSS 420B
Committee on Educational Technologies*	7–8:30 a.m.	STSS 432A
Committee on Graduate Education in Physics*	7–8:30 a.m.	STSS 432B
Committee on Science Education for Public*	7–8:30 a.m.	STSS 131B
Review Board	12–1:30 p.m.	STSS 123
Physics Bowl Advisory Committee	12–1:30 p.m.	STSS 144
Committee on Apparatus*	6–7:30 p.m.	STSS 420B
Committee on Physics in High Schools*	6–7:30 p.m.	STSS 312
Committee on International Physics Education*	6–7:30 p.m.	STSS 432A
Committee on Professional Concerns*	6–7:30 p.m.	STSS 432B
Committee on Space Science and Astronomy*	6–7:30 p.m.	STSS 131B
PTRA Advisory Committee	8:30–10 p.m.	Tate Lab 157
ALphA Committee	8:30–10 p.m.	Coffman Union - 323

Tuesday, July 29

Committee on Governance Structure (COGS)	7–8 a.m.	STSS 420B
Bauder Endowment/Venture Committee	7–8 a.m.	STSS 119
Committee on Laboratories*	11:30 a.m.–1 p.m.	STSS 420B
Committee on History & Philosophy in Physics*	11:30 a.m.–1 p.m.	STSS 512B
Committee on Physics in Pre-High School Ed.*	11:30 a.m.–1 p.m.	STSS 432B
Committee on Research in Phys. Ed. (RiPE)*	11:30 a.m.–1 p.m.	Tate Lab 133
Committee on Physics in Two-Year Colleges*	11:30 a.m.–1 p.m.	STSS 512A

Wednesday, July 30

Awards Committee (Closed)	7–8:30 a.m.	Commons Hotel - Think 4
Programs Committee II	7–8:30 a.m.	Commons Hotel - Pathways
Membership and Benefits Committee*	11:30 a.m.–1 p.m.	Tate Lab 157
SI Units and Metric Education Committee*	11:30 a.m.–1 p.m.	Tate Lab 143
Nominating II Committee (Closed)	3–4:30 p.m.	Commons Hotel - Think 1
Executive Board III	3–5:30 p.m.	Commons Hotel - Think 4

Free Commercial Workshops

CW01: PASCO Capstone: Simple and Powerful Data Analysis for Physics

Location: STSS 131B
Date: Monday, July 28
Time: 12–1 p.m.
Sponsor: PASCO scientific

Leaders: Ann Hanks, Brett Sackett

Regardless of where your data comes from, come get hands-on with Capstone and see how useful this software is for analysis. Easy data import and powerful tools streamline data analysis for physics. See why Capstone is the ultimate tool for the physics lab and classroom. See what is new and get a sneak peak at what's coming next. One lucky attendee will win a Capstone site license.

CW02: Put Your Online Physics Lab Courses in Motion!

Location: STSS 530A
Date: Monday, July 28
Time: 12–1 p.m.
Sponsor: eScience Labs LLC

Leaders: Dr. Stephen Ray, Dr. Nicolas Benedict

Have you considered creating online science lab courses but struggled to provide academically sound labs, hands-on experiences and support accreditation standards? We will demonstrate and share a redesigned physics lab curriculum for online students taking conceptual and general physics courses. Participants will interact with the hands-on and engaging eScience lab kits through demonstrations of highlighted physics labs. We will discuss challenges of teaching online physics courses and incorporating a laboratory component. We will respond to those challenges as well as perspective on the benefits to students. Participants will have an opportunity to share perspectives, ask questions and explore issues.

CW03: Increasing Student Success and Retention Using Comprehensive Peer-Reviewed, Customizable, Open Education Resources

Location: STSS 432A
Date: Tuesday, July 29
Time: 11:30 a.m.–12:30 p.m.
Sponsor: OpenStax College

Leader: Nicole Finkbeiner

Studies have shown that students are increasingly foregoing purchasing textbooks and other required resources due to costs and accessibility. In this workshop, attendees will learn about peer-reviewed open education resources, including the free, peer-reviewed *College Physics* textbook, and how faculty members across the country are increasing student success and retention using these resources. Customizing *College Physics* with OpenStax's redesigned, user-friendly authoring and editing platform will also be discussed.

CW04: PASCO Capstone: Simple and Powerful Data Analysis for Physics

Location: STSS 131B
Date: Tuesday, July 29
Time: 11:30 a.m.–12:30 p.m.
Sponsor: PASCO scientific

Leaders: Ann Hanks, Brett Sackett

Regardless of where your data comes from, come get hands-on with Capstone and see how useful this software is for analysis. Easy data import and powerful tools streamline data analysis for physics. See why Capstone is the ultimate tool for the physics lab and classroom. See what is new and get a sneak peak at what's coming next. One lucky attendee will win a Capstone site license.

CW05: Perimeter Institute: A New Spin on Classical Physics

Location: STSS 131A
Date: Monday, July 28
Time: 12–1 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope, Kevin Donkers

Are you looking for new and innovative ways to spice up classical physics concepts and expose your students to hands-on, modern physics without taking up extra time? This session explores how your everyday classical physics lessons can easily be connected to interesting concepts in modern physics including relating dark matter to circular motion, nuclear physics using electric fields, and how to detect subatomic particles using conservation of momentum. All activities presented connect to the new NGSS Standards.

CW06: Perimeter Institute: Hands-on Wave-Particle Duality

Location: STSS 131A
Date: Monday, July 28
Time: 1:30–2:30 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope, Kevin Donkers

The wave-particle duality is one of the deepest mysteries of quantum mechanics. Come explore hands-on activities that introduce students to this vitally important concept in the quantum world. Perimeter's The Challenge of Quantum Reality classroom resource is developed in collaboration with educators and PI researchers with connections to the new NGSS Standards.

CW07: Perimeter Institute: Beyond the Atom: Remodelling Particle Physics

Location: STSS 131A
Date: Tuesday, July 29
Time: 11:30 a.m.–12:30 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope, Kevin Donkers

The discovery of the Higgs boson was one of the biggest physics announcements of our generation. Join us as we explore concepts of momentum, charge, and fields being applied to modern particle physics. Perimeter's Beyond the Atom: Remodelling Particle Physics classroom resource is developed in collaboration with educators and PI researchers with connections to the new NGSS Standards.

CW08: Perimeter Institute: Cosmic Mysteries

Location: STSS 131A
Date: Tuesday, July 29
Time: 1–2 p.m.
Sponsor: Perimeter Institute

Leaders: Dr. Damian Pope, Kevin Donkers

Join Perimeter's NEWEST workshop designed to help teachers and students unravel the mysteries of space and the universe. This session shares hands-on activities focused on the big bang theory, expanding universe, black holes, redshift, cosmic microwave background, and more. Perimeter's Cosmic Mysteries classroom resource is developed in collaboration with educators and PI researchers with connections to the new NGSS Standards.

CW09: Vernier Software: Data Collection Tools for Physics, Including LabQuest2, the Motion Encoder System, and Vernier Data Share for iOS and Android

Location: Coffman Union President's Room
Date: Tuesday, July 29
Time: 11:30 a.m.–1:30 p.m.
Sponsor: Vernier Software & Technology

Leaders: David Vernier, Fran Poodry, John Gastineau

Attend this hands-on workshop to learn about LabQuest 2 and other new data collection tools from Vernier Software & Technology. We will start with and interactive presentation to show you how Vernier data collection works with both LabQuest and computer, and how the data can be shared with iPad or Android tablets, phones, and other computers. Then, we will make available a variety of new and interesting Vernier apparatus for you to investigate individually. a) Use the LabQuest 2 interface, and see its large color touch screen with the updated LabQuest App. b) Collect and analyze data on an iPad, Android tablet, or phone—ours or yours. c) Test the new Vernier Motion Encoder System, and see just how good dynamics cart data can be. d) Collect data with the Vernier Diffraction Apparatus, and see just how easy it is to map out intensity for single-slit and double-slit patterns. e) Perform a conservation of angular momentum experiment using our Rotary Motion Sensor. f) Collect wind turbine data using the New Vernier Energy Sensor with Kidwind turbines. g) Review the second edition of Physics with Vernier. h) Do some video analysis using Vernier Video Physics on iPad.

CW10: Closing the Gap between Homework and Test Scores with ExpertTA and OpenStax College

Location: Coffman Union Mississippi Room
Date: Tuesday, July 29
Time: 12-1 p.m.
Sponsor: The Expert TA

Leader: Jermy Morton

The delta between students' homework grades and test scores is a concern we share with you. What do these gaps tell us about student retention, student understanding, and our assessment strategies? Expert TA has investigated these gaps for the last several years and found that major factors are access to immediate, meaningful feedback and practice on symbolic questions. Knowing this, Expert TA has developed the largest available library of problems that require students to enter symbolic and algebraic responses. Additionally, our system provides exclusive "true" partial credit grading. Our math engine identifies detailed mistakes within students' symbolic answers, deducts points, and provides specific Socratic feedback. Access to high quality open resources can also close the gap. ExpertTA is proud to partner with OpenStax College and to be the only homework system including every problem from their book, College Physics. OpenStax College is a Rice University based nonprofit organization committed to improving student access to quality learning materials. OpenStax College Physics is extensive peer-reviewed, readable, accurate, and meets the scope and sequence requirements of your course. Please join us and learn how other instructors are using these integrated resources to reduce cost to students, increase academic integrity, and improve overall outcomes.

CW11: Making Holograms for Cool Physics Impact

Location: STSS 530A
Date: Tuesday, July 29
Time: 11:30 a.m.–12:30 p.m.
Sponsor: Liti Holographics

Leader: Paul Christie

Making holograms is one of the best demonstrations of the wave nature of light, including interference, diffraction, wavelengths, and coherence, ...but your students will just think it's cool! While you are demonstrating the high-level science that won a Nobel Prize for its advancement in the field of Physics, ...your fellow teachers and administrators will just be impressed that you make learning physics fun. And although you are showing real world applications of basic science principles, ...parents will just be amazed that their kids came home talking about science. Liti Holographics will demonstrate their easy to use Litiholo Hologram Kit for making real 3D laser holograms in a classroom. You'll get a hands-on look at the process for making holograms, and see the "Instant Hologram" Film at work. And we'll make holograms!

CW12: How WebAssign's Online Homework Can Help You Achieve Your Pedagogical Goals

Location: STSS 119
Date: Tuesday, July 29
Time: 11:30 a.m.–12:30 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. Through our partnerships with all major academic publishers, WebAssign supports over 150 introductory physics textbooks with homework questions and advanced learning tools. Additionally, WebAssign provides question collections authored by experienced physics educators and designed to strengthen student skills and conceptual understanding. Learn about our free physics resources, including companion content for select textbooks with feedback and tutorials, research-based collections that stress physics education research principles, and direct measurement videos that help students to connect real-world scenarios with classroom physics. Also discover the innovative ways that WebAssign can be used in labs and online courses.

CW13: Pearson Workshop: Eugenia Etkina

Location: STSS 210
Date: Monday, July 28
Time: 12-1 p.m.
Sponsor: Pearson

Leader: Eugenia Etkina

In accordance with the new 2015 MCAT, Next Gen Science Standards and new AP exam, the workshop will offer instructional methods on how to teach students to think like scientists by focusing on teaching the skills scientists use in their everyday work—analyzing data, observing patterns, testing predictions—using examples from the authors new College Physics textbook. Attendees will leave the workshop with several concrete assignments they can pilot in their next teaching cycle.

Need a wheel chair or scooter during the conference?
You can rent one from the Mobility Shop. Quantities are limited, so don't delay and 48 hours notice is needed. A scooter or wheel chair will be delivered to your hotel.

Rental Fees:

- $50 per day for motorized scooter or wheel chair.
- $20 per day for manual wheel chair.
- Minimum order is $100

Call 888-404-5554 to reserve your scooter or wheel chair!

AAPT Journals

Booth #207
One Physics Ellipse
College Park, MD 20740
301-209-3300
mgardner@aapt.org
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 the *American Journal of Physics* and *The Physics Teacher*. It is rumored that it may be possible to catch up with journal editors and other members of the Publications Committee during your visit. If you are an online-only member, you'll get a chance to see the print copies and reconsider your choice. If you aren't yet an AAPT member, we will do our best to help you decide which option is best for you.

American Association of Physics Teachers

Booths #201, 203, 205
One Physics Ellipse
College Park, MD 20740
301-209-3300
rrosier@aapt.org
www.aapt.org

Welcome to Minneapolis! Stop by the AAPT booth and spin the wheel for your chance to win some awesome prizes! We will have plenty of resources available to meet the needs of everyone from early career professionals to the more seasoned attendee. Check out the latest and greatest items from The Physics Store catalog including publications, AAPT-branded merchandise, especially our new t-shirts, and as always, a limited collection of Member-Only items. Items will be available for purchase at the booth, many at a tremendous savings. Lastly, do not forget to pick up your ticket for the Great Book Giveaway!

American 3B Scientific

Booth #308
2189 Flintstone Drive, Unit O
Tucker, GA 30084
andrea.quinlan@a3bs.com
770-492-9111
www.3BScientific.com

Visit 3B Scientific's booth #308 for innovative physics products designed to inspire students, release their creative spirits, and challenge their critical thinking skills. Come check out our STEM focused experiments, alternative energy products, and 3B's unrivaled line of Teltron® electron tubes and atomic spin resonance devices. Go one step further... and find what you're looking for!

Arbor Scientific

Booth #302
P.O. Box 2750
Ann Arbor, MI 48106
800-367-6695
Mail@arborsci.com
www.arborsci.com

Arbor Scientific shares the same passion for physics as you, and has for over 25 years. We love finding all the gadgets, lab equipment, and toys that will help you get your students excited about learning physics. Whether you're a veteran educator or just starting out as a science teacher, we have loads of cool tools to help you feel confident in what you're teaching!

CAEN Technologies, Inc.

Booth #309
1140 Bay St., Suite 2C
Staten Island, NY 10305
718-981-0401
sales@caen.it
www.caentechnologies.com

The CAEN Educational Kit is a modular, digital, flexible platform for teaching the fundamentals of Statistics and Particle Detections. Based on Silicon Photomultipliers and Digital Pulse Processing, it makes available the most advanced detection techniques available nowadays. An ultra fast LED Driver, a Scintillating Tile and a Spectrometer allow for multidisciplinar lab experiences presented in dedicated Educational Notes.

CourseWeaver Corp.

Booth #412
325 East Grand River Ave., Suite 355
East Lansing, MI 48823
866-343-3124
info@courseweaver.com
www.courseweaver.com

CourseWeaver, a provider of innovative learning solutions, delivers a next-generation LMS/CMS/LCMS including a homework/testing solution that pairs easy start class templates and embedded textbook materials from major publishers with a powerful tool set for K-12 and university educators. It features the most advanced physics/math engine, with revolutionary student and content metrics.

eScience Labs

Booth #311
1500 W. Hampden
Sheridan, CO 80110
303-741-0674
ebaker@esciencelabs.com
www.esciencelabs.com

eScience Labs LLC. provides complete and comprehensive hands-on science kits to support online and traditional courses in need of a laboratory solution. These are the same experiments you would find in a traditional academic lab, but designed and scaled to be performed by students anytime, anywhere. Written by PhD-level educators and scientists, our labs compliment any teaching style or curriculum. www.esciencelabs.com

Health Physics Society

Booth #210
1313 Dolley Madison Blvd., Suite 402
McLean, VA 22101
703-790-1745
hps@burkinc.com
www.hps.org

The Health Physics Society (HPS), formed in 1956, is a scientific organization of professionals who specialize in radiation safety. Through the Society's Science Support Committee, we provide outreach and support to science teachers through information, collaboration, resources, and tools at little or no cost to the teacher.

Interactive Video Vignettes Project

Booth #214
2120 Carlson Hall at RIT 54 Lomb Memorial Dr.
Rochester, NY 14623
585-475-6578
Robert.Teese@rit.edu
IVV.rit.edu

NSF-supported projects at RIT, Dickinson College and Bethel University are bringing new forms of active learning online! Come by and find out how to use our interactive, web-based activities in both introductory courses and advanced labs. You can even make your own by downloading free software from ComPADRE.

Iowa Doppler Products

Booth #408
2201 Dubuque Road
Iowa City, IA 52244
319-338-0836
idp@iowadoppler.com
www.iowadoppler.com

Instructional tools for teaching wave theory with ultrasound. Displayed will be demonstrations of acousto-optics, grating and single slit diffraction of ultrasound, a broadband hydrophone, and measurement of the speed of sound in liquids and solids. Bring a sample of material and we will measure its elastic properties for you.

Laser Classroom

Booth #211
1419 Main St. NE
Minneapolis, MN 55413
763-234-0692
colette@laserclassroom.com
www.laserclassroom.com

Laser Classroom creates resources, partnerships, and products to make teaching and learning about Light, Lasers, and Optics clear, easy, and affordable. Home of LASER Blox, the stackable laser designed just for teaching and learning.

Liti Holographics

Booth #410
300 Ed Wright Lane, Suite C
Newport News, VA 23606
757-873-6460
info@litiholo.com
www.litiholo.com

Holograms are exciting and attention-grabbing tools for teaching basic principles of light, optics, diffraction, interference, and so much more. Liti Holographics produces an easy-to-use Hologram Kit that has everything you need to make real 3D laser holograms in a classroom, including "Instant Hologram" Film Plates.

Modus Medical Devices, Inc.

Booth #305
1570 North Routledge Park
London, ONT, Canada N6H 5L6
519-438-2409
nglover@modusmed.com
www.modusmed.com

DeskCAT™ is an educational CT Scanner designed for students to safely explore the physics and principles of medical imaging in a classroom or laboratory setting. DeskCAT's™ scanner and software platform comes complete with 10 scanning phantoms, 20 hours of lab exercises and an unlimited software license.

OpenStax College

Booth #310
6100 Main St. MS-375
Houston, TX 77005
713-348-3674
info@openstaxcollege.org
www.openstaxcollege.org

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.

PASCO scientific

Booths #101,102,103,104
10101 Foothills Blvd.
Roseville, CA 95747
800-772-8700
sales@pasco.com
www.pasco.com

Join us to celebrate PASCO scientific's 50th anniversary in the exhibit hall. It was 50 years ago when Paul Stokstad, founder and president of PASCO, began to sell PASCO's first Millikan apparatus which he designed and built for a school science project. Now PASCO has over 1800 products ranging from string to e/m apparatus. As part of our celebration, we will give away one 850 Universal Interface and a PASCO Capstone Single License at each of our two workshops.

Pearson

Booth #406
1 Lake St.
Upper Saddle River, NJ 07458
480-457-6017
cindy.diaz@pearson.com
www.pearsonhighered.com

As the leading learning company in physics and astronomy, with trusted and tested content and the most widely used and proven physics homework, tutorial, and assessment system available, our goal is to partner with instructors, authors, and students to create innovative content and tools to improve student achievement.

Perimeter Institute

Booth #306
31 Caroline St. N.
Waterloo ONT, Canada N2L 2Y5
519-569-7600 x 5090
twilliams@perimeterinstitute.ca
www.perimeterinstitute.ca

Perimeter Institute for Theoretical Physics is an independent, nonprofit 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.

Sapling Learning

Booth #202
211 East 7th St., 4th Floor
Austin, TX 78701
512-323-6565
sales@saplinglearning.com
www.saplinglearning.com

Created and supported by educators, Sapling Learning's instructional online homework drives student success and saves educators time. Sapling Learning provides content for algebra- and calculus-based introductory physics courses, as well as conceptual physics. In addition to numeric and equation-based questions, conceptual understanding is measured using sorting, labeling, ranking, multiple choice, and multiple select answer types. To learn more, visit www.saplinglearning.com.

Society of Physics Students

Booth #209
One Physics Ellipse
College Park, MD 20740
301-209-3008
lydia@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 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 80,000 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, research awards, physics project awards, outreach/service awards for undergraduate students and a Summer Science Research Clearinghouse, where thousands of summer research positions are listed.

Spectrum Techniques

Booth #304
106 Union Valley Road
Oak Ridge, TN 37830
865-482-9937
sales@spectrumtechniques.com
www.spectrumtechniques.com

Spectrum Techniques, the leading supplier of nuclear counting equipment and Exempt Quantity radioisotopes, is pleased to announce new application software for Windows 64-bit and Macintosh OS-X operating systems. All of our current instruments are now compatible with the latest Windows and Macintosh computers. Visit us at booth 304.

TEL-Atomic, Inc.

Booth #204
1223 Greenwood Ave.
Jackson, MI 49203
517-783-3039
joe.dohm@telatomic.com
www.telatomic.com

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

The Expert TA

Booth #307
624 South Boston, Suite 220
Tulsa, OK 74119
918-949-4190
main@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 401 for a demonstration.

The Science Source

Booth #208
299 Atlantic Highway
Waldoboro, ME 04572
800-299-5469
paulrogers@thesciencesource.com
www.thesciencesource.com

The Science Source is the Maine-based manufacturer enhancing science literacy by creating and providing high-quality, high-value science teaching materials. The Science Source is featuring its Physics lines this year in AAPT Booth 208, including new releases Digital Display unit and Laser Dynamic Glider System for air tracks.

The Universe and More

37 Hill St. A1
Morristown, NJ 07960
973-943-9016
Matthewblackman1@gmail.com
Theuniverseandmore.com

Get your kids excited about physics! The Universe and More is your source for educational games that are actually fun!

University of Minnesota

Booth #212
Twin Cities
Minneapolis, MN 55455
612-625-5000
http://www1.umn.edu/twincities/contact/
http://www.umn.edu

The University of Minnesota, one of the largest public research universities in the country, offers a multitude of certificate and degree programs, both on-campus and online, for educators of all levels. Programs range from study in science and engineering to STEM education to teaching a diverse student body to educational policy and administration.

Vernier Software & Technology, Inc.

Booths #301, 303
13979 SW Millikan Way
Beaverton, OR 97005
888-837-6437
info@vernier.com
www.vernier.com

Vernier Software & Technology has been producing data-collection hardware and software for over 30 years. Stop by our booth to see our LabQuest 2, the heart of our Connected Science System, and our other great new products. You can also enter to win your own LabQuest 2.

W.H. Freeman & Co.

Booth #404
41 Madison Ave.
New York, NY 10010
212-576-9400
Jacqueline.Seltzer@macmillan.com
www.whfreeman.com/physics

W.H. Freeman, a Macmillan Education company, works with instructors, authors, and students to enhance the physics teaching and learning experience. Visit us to learn more about College Physics, smartPhysics, and other innovative teaching tools. Booth #404. www.whfreeman.com/physics.

Ward's Science/Cenco Physics

Booth #312
5100 West Henrietta Road, P.O. Box 92912
Rochester, NY 14692
800-962-2660
wardscs@vwr.com
www.wardsci.com/physics

Introducing the widest selection of hands-on physics activities, curriculum-based kits, and high-quality apparatus for beginner to advanced level physics: 3X more activities and apparatus than any other supplier—over 4,300 items with 120 new products! 24 standards-aligned AP Physics Investigations CENCO Physics products, now exclusively available from Ward's Science. Learn more at wardsci.com/physics.

WebAssign

Booth #402
1791 Varsity Drive, Suite 200
Raleigh, NC 27606
919-829-8181
aknight@webassign.net
www.webassign.net

WebAssign is your indispensable partner in education. Providing exceptional online homework and grading solutions since 1997, WebAssign has been a vital part of the physics community from its inception. Teachers have easy access to precoded questions from every major textbook and publisher, additional question collections from leading physics education researchers, customizable labs, and free resources including direct-measurement videos.

APS Education & Diversity

Location TBD
1 Physics Ellipse
College Park, MD
khatib@aps.org
301-209-3297
www.aps.org

The American Physical Society has resources for every physics educator! Faculty can learn about APS education and diversity programs. Teachers can register for our middle school science adventure, adopt physicists for your high school class, pick up free posters, and much more.

SHARED BOOK EXHIBIT

University of Chicago Press

1. Vincent Icke, *Gravity Does Not Exist*
2. James W. Cronin, *Fermi Remembered*
3. Steven Vogel, *The Life of A Leaf*
4. Allen Everett and Thomas Roman, *Time Travel & Warp Drives*

AAPT Physics Education

Monday, July 28, 2014 – Session Schedule

Session Rooms are in the STSS Building or Tate Lab at UM – Poster Session I is in Coffman Memorial Union, 8:30 to 10 p.m.
PIRA Resource Room: Coffman Memorial Union, Great Hall Annex Exhibit Hall: Coffman Memorial Union Great Hall

	STSS 220	STSS 330	STSS 114	STSS 412	STSS 230	Tate Lab 131	Tate Lab 133	Tate Lab 166	Tate Lab 170	STSS 312	STSS 420B	Tate Lab 210	STSS 432A	Northrop Auditorium
8:30 a.m.	**AA** High School Topics	**AB** Historical Perspectives on Teaching Physics	**AC** Creating Research-like Experiences for All Students	**AD** Physics in a Biological Context	**AE** PER in Upper Division Physics	**AF** Teacher Training and Enhancement	**AG** The Impact of the GRE and Graduate Admissions on Diversity in Graduate School	**AH** Getting Started in PER	**AI** Introductory Labs and Apparatus					
9:00 a.m.														
9:30 a.m.														
10:00 a.m.														
10:30 a.m.														**Awards:** AAPT Teaching Awards; DSCs
11:00 a.m.														
11:30 a.m.														
12:00 p.m.											**TOP02** Troubleshooting Apparatus	**TOP03** Physics and Society Topical Discussion	**TOP04** PER Solo Faculty	
12:30 p.m.														
1:00 p.m.														
1:30 p.m.	**BB** PER: Exploring Problem Solving Approaches and Skills	**BI** **Panel** – Two Year College New Faculty Experience: Commencement Conference Update	**BJ** Physics of Phun	**BH** Preparing Physics Teachers to Teach in Diverse Environments	**BE** PER in Upper Division Physics II	**BD** Teaching Advanced/Honors Students	**BF** Outreach: Fun Ways to Engage	**BG** K-12 PER	**BC** Creating Research-like Experiences for All Students II	**BA** **Panel**– MOOCs and You		**TOP01** YouTube Share-a-thon	**NOTE:** **TOP05** iOS and Android App Show is in ***STSS 131B 4–5:30 p.m.***	
2:00 p.m.														
2:30 p.m.			**BK** Making Physics Phun											
3:00 p.m.														
3:30 p.m.														
4:00 p.m.	**CB** Incorporating Metacognition in Physics Instruction and Assessing Outcomes	**CA** **Panel** – Educational Technology Highlights from MPTL	**CJ** Using Games to Teach Physics	**CG** Translating Teachers' Research Experience into Classroom Practice	**CE** Art and Science of Teaching	**CI** Upper Division and Graduate Courses and Labs	**CC** **Panel –** The Work of the Undergraduate Curriculum Task Force	**CF** Physics and Society: Current Topics in Energy	**CH** **Panel –** Confessions of a First Year Faculty Member	**CD** Perspectives in Particle Physics				
4:30 p.m.														
5:00 p.m.			**CK** Interactive Lecture Demonstrations											
5:30 p.m.														
6:00 p.m.								**TOP06** Grad Students						
7:00 p.m.														
7:30 p.m.														**Plenary**
8:30: p.m.														

Tuesday, July 29, 2014 – Session Schedule

Session Rooms are in the STSS Building or Tate Lab at UM – Poster Session I is in Coffman Memorial Union, 5 to 6:30 p.m.
PIRA Resource Room: Coffman Memorial Union, Great Hall Annex Exhibit Hall: Coffman Memorial Union Great Hall

	STSS 220	STSS 330	STSS 114	STSS 412	STSS 230	Tate Lab 131	Tate Lab 133	Tate Lab 166	Tate Lab 170	STSS 312	STSS 420A	Northrop Auditorium
8:00 a.m.	**DG** PER: Evaluating Instructional Strategies I	**DD** Assessment Issues in Undergraduate Instruction	**DB** Sustainability of Physics Teacher Prep Programs	**DE** Developing Experimental Skills in the Introductory Lab	**DA** Teaching the Women in Physics Course	**DJ** Reform Dissemination	**DH** Electronic Lab Notebooks		**DF** Stories, Replicas, & Kits	**DC** Broader Perspectives on Research in Learning Quantum Mechanics		
8:30 a.m.												
9:00 a.m.						**DK** If They Build It, They Will Learn	**DI** Arduinos, Micro-Controllers					
9:30 a.m.												
10:00 a.m.												
10:30 a.m.												
11:00 a.m.												**Klopsteg Lecture Award**
11:30 a.m.												
12:00 p.m.												
12:30 p.m.											Easy JavaScript Simulations	
1:00 p.m.												
1:30 p.m.	**ED** PER: Diverse Investigations	**EA** Bridging Research and Teaching through Computation	**EH** Histories Useful for Teaching Physics	**EC** Teachers in Residence	**EI** Best Practices in Educational Technology I	**EF** The Role and Implementation of Upper-level E&M		**EG** What Can PER Contribute to the Design of High Quality Distance Education?	**EE** Same Physics Other Ways	**EB** Physics in a Biological Context II		
2:00 p.m.					**EJ** Technologies							
2:30 p.m.												
3:00 p.m.												
3:30 p.m.												
4:00 p.m.												**APS Plenary**
4:30 p.m.												
5:00 p.m.												
5:30 p.m.												
6:00 p.m.												
7:00 p.m.												
7:30 p.m.												
8:30: p.m.												

Wednesday, July 30, 2014 – Session Schedule

Session Rooms are in the STSS Building or Tate Lab at UM. Poster Session, post-deadline: 1-2:30 p.m. in Coffman Union

	STSS 220	STSS 330	STSS 114	STSS 412	STSS 230	Tate Lab 131	Tate Lab 133	Tate Lab 166	Tate Lab 170	STSS 312	Northrop Auditorium
8:30 a.m.	**FH** Mentoring in the Physics Community	**FA** Remembering John Risley	**FG** Broader Perspectives: Research-based Strategies to Improve the Teaching and Learning of Physics and Astronomy	**FB** Seeking Employment in Academia		**FD** Introductory Courses	**FE** Magnetism and Thermal Labs, Beyond First Year	**FF** PER: Modeling Sudent Engagement	**FC** Reform Dissemination: Successful Examples II	**FJ** Strategies for Teachers and Professors to Support Female Students	
9:00 a.m.											
9:30 a.m.											
10:00 a.m.	**FI** Teacher Communities									**FK** Supporting Female Students	
10:30 a.m.											
11:00 a.m.											**Millikan Medal**
11:30 a.m.											
12:00 p.m.		**TOP11** Conference on Women in Physics	**TOP08** Web Resources for Astronomy		**TOP09** Physics on the Road			**TOP07** PERTG Town Hall			
12:30 p.m.											
1:00 p.m.											
1:30 p.m.	**GA** PER: Examining Content Understanding and Reasoning	**GB** A Potpourri of Physics and Physics Teaching Ideas	**GI** Post-deadline Session III	**GC** Best Practices in Educational Technology II		**GE** PER: Evaluating Instructional Strategies II	**GG** Post-deadline Session I	**GH** Post-deadline Session II	**GD** Bridging Engineering, Math, and Physics	**GF** Introductory Courses II	
2:00 p.m.											
2:30 p.m.											
3:00 p.m.											
3:30 p.m.											**PERC** PERC Bridging Session
4:00 p.m.											
4:30 p.m.											
5:00 p.m.											
5:30 p.m.											
6:00 p.m.											
7:00 p.m.											
7:30 p.m.											
8:30: p.m.											

AAPT Instagram Scavenger Hunt

Here's your mission, should you choose to accept it. Capture images of the below clues for a chance to win a **$100 American Express Gift Card** or a **$25 Amazon gift card**. Must have an Instagram account to participate.

1. AAPT Executive Officer
   Beth Cunningham
2. Selfie with First Time Attendee
   aka a "New Bee"
3. Body of Water
4. Local Minneapolis Landmark
   (Extra points: Spoonbridge and Cherry)
5. Item invented in Minnesota
   (i.e. Scotch Tape, Wheaties, Bisquick, or Bundt Pan)
6. Red Bull's Eye
   (Target is HQ'd in Minneapolis)
7. Selfie with meeting attendee
   who is NOT from the U.S.
8. Sherlock Holmes literature, artifact, memorabilia from University of Minnesota's Andersen Library
9. Can of SPAM
   (There's a SPAM Museum in Austin, MN)
10. Mall of America Roller Coaster

Post these photos using the hashtags
#AAPTSM14 and **#ScavengerHunt**.

Scavenger Hunt Photos Must Be Taken & Posted July 25-30, 2014
Winners will be announced on August 1, 2014 via Instagram.

Questions?
Email: marketing@aapt.org
Visit: AAPT Booth (#201-203)

AAPT
PHYSICS EDUCATION

#AAPTSM14

Workshops – Saturday, July 26

All workshops are held at the University of Minnesota

T01: Not Everyone Wants to go to Graduate School: How to be an Effective Mentor for "the Other 40%"

Sponsor: AAPT/SPS
Time: 9 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 117

Toni Sauncy, One Physics Ellipse, College Park MD 20740; tsauncy@aip.org

Roman Czujko

This workshop is intended to empower educators who have an interest in improving outcomes for undergraduate students who desire to enter the STEM workforce following the baccalaureate degree. The AIP Career Pathways project, funded by NSF, has identified a set of common features and developed mentoring guidelines for faculty and advisors that will be presented in this interactive workshop session. The content of the workshop is based on analysis of information gained during site visits to physics programs at a range of institution sizes, types and locations, all with a strong record of students who successfully found satisfying STEM employment following graduation.

T02: GlowScript: An Easy-to-use Programming Environment for 3D Browser Animations

Sponsor: Committee on Educational Technologies
Time: 1–3 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 312

Bruce Sherwood, 515 E. Coronado Road, Santa Fe NM 87505; Bruce_Sherwood@ncsu.edu

Using the web programming language JavaScript, it is now possible in modern browsers to use the WebGL graphics library to create 3D animations that run in a browser. However, WebGL is a very low-level library and is quite difficult to use directly. GlowScript, which is similar to the VPython programming environment (vpython.org), makes it easy to exploit the new capabilities of WebGL. For example, the one-line program "sphere()" displays a 3D sphere and permits zooming and rotating the view. The tutorial will offer a tour of GlowScript capabilities, including the writing of small programs that generate 3D animations. For more information, and to see some physics demos, visit glowscript.org and glowscript.org/#/user/Bruce_Sherwood/folder/MI/.

W01: Morning Tour of the Bakken Museum

Sponsor: Committee on History and Philosophy in Physics
Time: 8 a.m.–12 p.m. Saturday
Member Price: $10 **Non-Member Price:** $10
Location: offsite

Shawn Reeves; shawn@shawnreeves.net

David Rhees

Explore the connections between history, science, and engineering at this beautiful mansion and gardens. The Bakken houses the world's leading collection of books and artifacts on the history of electricity in life. A bus will take us to the site on Lake Calhoun.

W02: Integrating Direct-Measurement Videos into Physics Instruction

Sponsor: Committee on Physics in Undergraduate Education
Co-sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Saturday
Member Price: $65 **Non-Member Price:** $90
Location: STSS 330

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

Matthew Vont

Direct Measurement Videos are short videos that students can analyze using physics concepts. Students make measurements directly from the videos using grids, rulers, frame-counters, and other graphic overlays. Because numerical values are not provided, direct-measurement videos give students an opportunity to engage in a more open-ended approach to problem solving. In this workshop, we'll share methods for using these videos as engaging problem-solving activities in introductory mechanics instruction. We'll see how direct-measurement videos change students' approach to problem solving. We'll share some fun and challenging activities to motivate students to stretch their ability to apply physics concepts to new situations. Both the Next Generation Science Standards (NGSS) and the new AP Physics 1 and 2 curriculum expect students to engage in a range of science practices. We'll demonstrate how students can use a single video to develop scientific thinking skills such as asking questions, collecting data, solving problems, and presenting results. Participants will need to bring their laptops and have QuickTime player installed.

W03: Open-Source Electronics for Laboratory Physics

Sponsor: Committee on Apparatus
Co-sponsor: Committee on Laboratories
Time: 8 a.m.–12 p.m. Saturday
Member Price: $140 **Non-Member Price:** $165
Location: Tate 215

Zengqiang Liu, 720 4th Ave. S WSB 324, St. Cloud, MN 56301; zliu@stcloudstate.edu

Open-source electronics are electrical circuits and devices whose designs are released to the public by the designers, so others may modify and improve them. Using open-source data acquisition electronics in laboratory physics will dramatically reduce the cost of laboratory electronics and empower instructors to develop new laboratory activities, demonstrations and exploratory projects with students. This workshop will improve participants' understanding of open-source electronics and their applications in laboratory physics. Many laboratory physics sensors and open-source devices will be introduced and demonstrated. The workshop provides hands-on experience in projects using laboratory physics sensors with an award-winning, low-cost, open-source electronic data acquisition platform. Attendees will acquire skills in circuit construction, soldering, computer programming and interfacing with sensors through these projects. Participants must bring a laptop. They can take home the open-source devices they use during the workshop.

W04: FPGAs in the Lab

Sponsor: Committee on Apparatus
Co-sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Saturday
Member Price: $75 **Non-Member Price:** $100
Location: Tate 65

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 that 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.

W06: Inquiring into Radioactivity for Radiation Literacy

Sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Saturday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 512B

Andy Johnson, CAMSE Unit 9005, BHSU, 1200 University Spearfish, SD 57799-9005; Andy.Johnson@BHSU.EDU

Nonscience majors CAN learn about radioactivity and ionizing radiation! The Inquiry into Radioactivity (IiR) Project has created a complete set of inquiry-based course materials for non-science H.S. and college students to learn about radiation. It's time for radiation literacy. Fun, research-based activities and powerful simulators help students gain fundamental understandings of radiation, atoms, ionization, and other issues. Students work out distinctions between EM and ionizing radiation, they discover the particulate character of radiation, and formulate basic models for beta and alpha emission. Most importantly, they abandon the contamination view of radiation and develop explanations for how radiation harms tissue. Participants will receive the complete IiR materials, also available at http://www.camse.org/radiation. The IiR project is supported by NSF DUE 0942699.

W08: Making Interactive Video Vignettes and Interactive Web Lectures

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Physics in Undergraduate Education
Time: 8 a.m.–12 p.m. Saturday
Member Price: $65 **Non-Member Price:** $90
Location: STSS 432A

Bob Teese, 2120 Carlson Hall, Rochester Institute of Technology, 54 Lomb Drive, Rochester, NY 14623; rbtsps@rit.edu

Priscilla W. Laws, 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. 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 video equipment and server you will need. (Supported by NSF grants DUE-1122828 and DUE-1123118.)

W09: Physics of Energy

Sponsor: Committee on Science Education for the Public
Co-sponsor: Committee on Physics in Two-Year Colleges
Time: 8 a.m.–5 p.m. Saturday
Member Price: $80 **Non-Member Price:** $105
Location: Tate 226

Abigail R. Mechtenberg; amechten@umich.edu

AAPT educators embrace this Physics of Energy workshop for experimental (laboratories) and theoretical (simulations) curricula. The academic level is set for undergraduate engineers and physicists; however, the astute teacher can easily apply this to other students. During the experimental part of the workshop laboratories will be executed in groups (starting with cookbook and moving to inquiry-based pedagogies through a novel experimental design approach). During the theoretical part of the workshop, Homer Energy microgrid activities will be executed. All participants will leave with a USB of resources. Together the workshop will weave a coherent common thread for our Physics of Energy from mechanical to electrical energy, thermal to electrical, solar to electrical, and chemical to electrical energy. Whether motivated by energy security or environmental stability, physicists at all levels must play an active role in the scientific literacy of energy integrated coherently and systematically without personal bias.

W10: AP Physics 1&2

Sponsor: Committee on Physics in High Schools
Co-sponsor: Committee on Teacher Preparation
Time: 8 a.m.–5 p.m. Saturday
Member Price: $185 **Non-Member Price:** $210
Location: STSS 432B

Martha Lietz, 2659 Hillside Lane, Evanston, IL 60201; marlie@d219.org

Connie Wells

The new AP Physics 1 and 2 workshops will be rolled out for the school year 2014-15 with the first exams given in May of 2015. This workshop will introduce the participants to the new curriculum and give them ideas for inquiry-based labs.

W11: Learning 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: $86 **Non-Member Price:** $111
Location: STSS 420B

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

David Brookes

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 (30 or more activities per textbook chapter for use with any textbook, including a new ISLE-based textbook) in lectures, recitations and homework; (b) a website with over 200 videotaped experiments and questions for use in lectures, recitations, 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. 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 someone who does.

W12: PIRA Demonstration Workshop I

Sponsor: Committee on Apparatus
Time: 8 a.m.–5 p.m. Saturday
Member Price: $115 **Non-Member Price:** $140
Location: Tate 150

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

Sam Sampere

Topics in this workshop cover the standard first semester of physics instruction from Mechanics to Thermal. It is taught by an experienced team of lecture demonstrators. The format allows for and encourages interplay 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 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. Please note that this workshop is intended to expose as many demonstrations and ideas as possible to the participants. Since we will be doing approximately 100 demos during this workshop, time restraints DO NOT allow for extensive or in-depth discussions of each demonstration. We will make every effort to answer all questions and concerns.

W13: Introductory Laboratories

Sponsor: Committee on Laboratories
Time: 1–5 p.m. Saturday
Member Price: $70 **Non-Member Price: $95**
Location: Tate 130

Mary Ann Klassen, Dept. of Physics & Astronomy, Swarthmore College, 500 College Ave., Swarthmore PA 19081; mklasse1@swarthmore.edu

Whether your lab curriculum is ripe for an overhaul or well-established, this workshop will provide new ideas to bring home to your institution. Six presenters from colleges and universities across the United States will each demonstrate their approach to a favorite introductory lab exercise. Attendees will have the opportunity to work with each apparatus. Documentation will be provided for each experiment, with lab manuals, sample data, equipment lists, and construction or purchase information. This workshop is appropriate primarily for college and university instructional laboratory developers.

W14: Afternoon Tour of the Bakken Museum

Sponsor: Committee on History and Philosophy in Physics
Time: 1–5 p.m. Saturday
Member Price: $10 **Non-Member Price: $10**
Location: offsite

Shawn Reeves; shawn@shawnreeves.net

David Rhees

Explore the connections between history, science, and engineering at this beautiful mansion and gardens. The Bakken houses the world's leading collection of books and artifacts on the history of electricity in life. A bus will take us to the site on Lake Calhoun.

W15: Activity-based Physics for the Advanced H.S. Classroom

Sponsor: Committee on Physics in High Schools
Time: 1–5 p.m. Saturday
Member Price: $68 **Non-Member Price: $93**
Location: Tate 225

Maxine Willis, Dickinson College, Department of Physics and Astronomy, Carlisle, PA 17013; willism@dickinson.edu

Priscilla W. Laws, Steve Henning

This hands-on work shop is designed for teachers in advanced physics classes (such as AP, International Baccalaureate and honors physics) who want to help students master concepts in mechanics through inquiry-based active learning. Participants will work with classroom-tested curricular materials drawn from the Activity Based Physics Suite (http://physics.dickinson.edu/~abp_web/abp_homepage.html). These Suite materials, based on the outcomes of physics education research, enable students to learn physics by collecting and analyzing data using flexible computer tools available from either Vernier or PASCO. Affordable access to the Suite materials for secondary school use is now available and will be discussed.

W16: Tinkering and Explorations in Science – Integrating Sensors and Data Acquisition with Arduino

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Apparatus
Time: 1–5 p.m. Saturday
Member Price: $110 **Non-Member Price: $135**
Location: Tate 140

Brian Huang, 6175 Longbow Drive, Boulder, CO 80301; brian.huang@sparkfun.com

At SparkFun, our focus is to excite the greater community to "tinker" and play with electronics. We strive to push the envelope for integrating electronics, technology, and programming into all populations. Using the simplicity and power of the open-source community, we will model several tools and hands-on demonstrations of physics experiments in the Arduino environment. One of the pillars of STEM education is to build, create, and invent. The Arduino platform is built around this idea and is easier than you think! We will explore areas of motion, forces, sound, and light with this low-cost microcontroller platform. We will also brainstorm ideas around teaching circuits, capacitance, and computer architecture through a variety of projects. Bring a laptop if you have one. We will have a limited number of laptops and hardware to give away.

W17: Energy in the 21st Century

Canceled

Sponsor: Committee on Space Science and Astronomy
Co-sponsor: Committee on Physics in Two-Year Colleges
Time: 1–5 p.m. Saturday
Member Price: $80 **Non-Member Price: $105**
Location: STSS 117

Pat Keefe, Clatsop Community College, 1651 Lexington Ave., Astoria OR 97103; pkeefe@clatsopcc.edu

Greg Mulder

We have found that engaging students in predictions of what form and how much energy will be used in the future is a very successful way to generate enthusiasm and further investigation of physics. Participants of this workshop will be introduced by way of experience to two different group projects that involve designing energy systems. These modeling exercises look at past energy consumption patterns and develop a plan for energy usage in the 21st Century. Other considerations such as population, costs and efficiencies are also used to further expand the discussion and decision-making that takes place.

W18: Tips for Putting Fire into Your Teaching

Sponsor: Committee on International Physics Education
Co-sponsor: Committee on Diversity in Physics
Time: 1–5 p.m. Saturday
Member Price: $60 **Non-Member Price: $85**
Location: STSS 131B

Michael Ponnambalam, 7-40 Sannathi St., Vadakkankulam Tirunelvely District, Tamil Nadu 627 116, INDIA; michael.ponnambalam@uwimona.edu.jm

The laws of physics are objective, and hence may seem cold and impersonal. However, their presentation is subjective. Hence, the communication of physics can vary from a "very boring" to a "very exciting" level, depending upon the skills of the presenter. Using dramatization, story-telling and a burning passion for physics, the presenter of this workshop has successfully communicated the beauty, the poetry, the wonder and the excitement of physics to numerous students in primary schools, high schools and universities, and has won awards for this. During this workshop, the participants will be given the opportunity to learn—and practice in small groups—the expert communication skills that will fill their teaching sessions with infectious enthusiasm and explosive energy. Further, they will learn—and practice in small groups—the details of the "holistic approach" which will raise their teaching to a "higher level."

W19: Skepticism in the Classroom

Sponsor: Committee on Physics in High Schools
Time: 1–5 p.m. Saturday
Member Price: $60 **Non-Member Price: $85**
Location: STSS 432A

Dean Baird, Rio Americano High School, 4540 American River Drive, Sacramento, CA 95864-6199; dean@phyz.org

Matt Lowry, College of Lake County, Lake Forest, IL

We will present a variety of lessons, appropriate for the physics classroom, that focus on the skeptical and critical thinking nature of science. Some lessons involve obvious physics content; some bring in examples from the real world. Participants will leave with ready-to-use lessons and resources designed to bring healthy, scientific skepticism to their classrooms—lessons that slip into content-based physics instruction without disruption. Topics include fire walking, ghosts and angels, balance bracelets, pareidolia, back masking, media credulity, and more.

W20: Introductory Physics for Life Science – Curricular Materials and Activities

Sponsor: Committee on Laboratories
Time: 1–5 p.m. Saturday
Member Price: $80 **Non-Member Price:** $105
Location: STSS 530B

Nancy Beverly, 555 Broadway, Mercy College, School of Health and Natural Sciences, Dobbs Ferry, NY 10522; nbeverly@mercy.edu

Nancy Donaldson, Ralf Widenhorn, Dan Young, Evan Frodermann, Kim Moore

The recent Conference on Introductory Physics for Life Science, the Gordon Physics Education Research Conference on the Complex Intersection of Physics and Biology, and the *American Journal of Physics* special issue on the Intersection of Physics with Biology, have all broadened the scope of possibilities for activities and implementation for the Introductory Physics for Life Science. This workshop will present highlights from these events, as well as resources and repositories for the increasing number of materials for activities and curricular ideas. Participants will have the opportunity to experience some activities and materials as well as discuss their implementation issues, particular to their student population needs and institutional challenges.

W21: Simple Experiments for Learning the Strategies that Mirror Science Practices

Canceled

Sponsor: Committee on Teacher Preparation
Co-sponsor: Committee on Physics in High Schools
Time: 1–5 p.m. Saturday
Member Price: $65 **Non-Member Price:** $90
Location: STSS 512B

Gorazd Planinsic, Faculty for Mathematics and Physics, University of Ljubljana, Jadranska 19 1000, Ljubljana, SLOVENIA; gorazd.planinsic@fmf.uni-lj.si

Bor Gregorcic

This is a hands-on workshop designed for teachers interested in using Investigative Science Learning Environment (ISLE) system to engage students in practical work that mirrors scientific practice and thus helps them develop scientific habits of mind. Creation of successful practical ISLE problems relies on finding suitable experiments. The key features of such experiments are that they are simple, easy to build, that they allow students construct multiple explanations within the accessible curriculum domain and that they provide opportunities for the students to actively experience how experiment and theory are interwound. Obviously the requirements are tough and therefore it is understandable why such experiments are not easy to find. In the workshop participants will be solving different problems based on simple experiments with computer scanner and mobile phones using ISLE approach. Participants will work in rotating groups. At the end there will be a discussion about the results.

Workshops – Sunday, July 27

All workshops are held at the University of Minnesota

W22: Activities for Learning About Climate and Climate Change

Sponsor: Committee on Science Education for the Public
Co-sponsor: Committee on Space Science and Astronomy
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 432B

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

Paul Williams

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.

W23: Creating Interactive Web Simulations Using HTML5 and JavaScript

Sponsor: Committee on Educational Technologies
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 530A

Dan Schroeder, Physics Department, Weber State University, 2508 University Circle, Ogden, UT 84408-2508; dschroeder@weber.edu

Andrew Duffy

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-do-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.

W24: Integrating NGSS, Design, and Literacy

Sponsor: Committee on Professional Concerns
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: STSS 144

Alice Flarend, 209 W 15th Ave., Altoona, PA 16601; amf@blwd.k12.pa.us

The Next Generation Science Standards (NGSS) call for integrating science content, practices, and engineering design. This workshop will allow the participants to explore engineering projects that tie in real science content, rather than guess and check methods, as well as highlighting science practices. The Claims, Evidence and Reasoning model of scientific communication will be used throughout. This workshop is appropriate for all pre-college science teachers as well as teacher educators. Post-secondary teachers may find the explicit evidenced-based scientific reasoning useful, particularly for laboratories at the college level.

W25: What Every Physics Teacher Should Know About Cognitive Research

Sponsor: Committee on Research in Physics Education
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: STSS 123

Chandralekha Singh, 221 A Allen Hall, Department of Physics, University of Pittsburgh, Pittsburgh, PA 15213; clsingh@pitt.edu

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

W26: Extreme Engineering for the H.S. Students & Teachers

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 432A

Ken Cecire, University of Notre Dame, Department of Physics, 225 Nieuwland Science Hall, Notre Dame, IN 46556; kenneth.w.cecire.1@nd.edu

The Next Generation Science Standards strongly emphasize scientific and engineering practices: this can be a challenge for physics teachers. Meet this head on using data and design from the Large Hadron Collider (LHC) at CERN. The LHC is not only at the forefront of physics research but comprises some of the greatest engineering marvels of the 21st century. We will use LHC data and design in scientific and engineering investigations for your classroom and help you meet the new standards.

W27: Patterns Approach

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $70 **Non-Member Price:** $95
Location: STSS 530B

Bradford Hill; bradford_hill@beaverton.k12.or.us

Heather Moore, Jordan Pasqualin

Offered by AAPT's 2014 Zitzewitz Award for Excellence in Pre-college Physics winner and collaborators. 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 are continually engaged in scientific practices, 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. 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 an experiential case for why we engage in scientific practices. Creating models and discussing their limitations is also key. The Patterns Approach has been used within freshman and IB courses and is published in the March issue of *The Science Teacher.*

W28: Teaching Astronomy with Mobile Devices

Sponsor: Committee on Space Science and Astronomy
Time: 8 a.m.–12 p.m. Sunday
Member Price: $20 **Non-Member Price:** $45
Location: STSS 330

Kevin Lee, 244D Jorgensen Hall, University of Nebraska, Lincoln, NE 68588-0299; klee6@unl.edu
Kendra Sibbernsen

This workshop will cover many of the issues concerning usage of mobile devices with students in astronomy classes. We will 1) survey the existing simulations and apps available for teaching astronomy concepts, 2) demonstrate and discuss experiences with Pearson's advanced peer instruction software Learning Catalytics, 3) discuss relevant issues such as what to do about students who don't have access to a mobile device and how you keep students from using their mobile devices for other purposes in the classroom, and 4) discuss recent trends in student ownership, use, and capability of mobile devices. Participants are encouraged to bring a relatively recent mobile device (smartphone or tablet). We would like to thank the NSF for funding under Grant No. 1044658.

W29: Demo Kit in a Box

Sponsor: Committee on Physics in High Schools
Time: 8 a.m.–12 p.m. Sunday
Member Price: $70 **Non-Member Price:** $95
Location: STSS 312

Steve Lindaas, 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 the 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. Participants will leave with demos and a box!.

W30: Interactive Engagement in the Upper Division: Methods and Materials from CU-Boulder

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Research in Physics Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $72 **Non-Member Price:** $97
Location: STSS 412

Steven Pollock, University of Colorado, Department of Physics, 390 UCB, Boulder, CO 80309; steven.pollock@colorado.edu

Charles Baily, Marcos (Danny) Caballero, 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)

W31: Strengthening Mathematical Sensemaking in Physics

Sponsor: Committee on Research in Physics Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 512B

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

Suzanne Brahmia, Stephen Kanim

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* 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 and engineering practices, but is often not well developed in traditional courses.

*D. Schwartz and J. Bransford, "A time for telling," *Cog. Instr*. **16** (4), 475 (1998).

W32: New RTP and ILD Tools and Curricula: Video Analysis, Clickers, and E&M Labs

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Research in Physics Education
Time: 8 a.m.–12 p.m. Sunday
Member Price: $75 **Non-Member Price:** $100
Location: Tate 225

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

Priscilla Laws, Ronald Thornton

RealTime Physics (RTP) and Interactive Lecture Demonstrations (ILDs) have been available for over 15 years—so what's new? The third edition of RTP includes five new labs on basic electricity and magnetism in Module 3 as well a new approach to projectile motion in Module 1. Some of these new labs make use of video analysis. Also new are clicker-based ILDs. This hands-on workshop is designed for those who want to make effective use of active learning with computer-based tools in their introductory courses. These active learning approaches for lectures, labs, and recitations (tutorials) are based on physics education research (PER). 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.

W33: PIRA Demonstration Workshop II

Sponsor: Committee on Apparatus
Time: 8 a.m.–5 p.m. Sunday
Member Price: $115 **Non-Member Price:** $140
Location: Tate 150

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

Sam Sampere

Topics in this workshop cover the standard second semester of physics instruction from E&M to Modern plus Astronomy. It is taught by an experienced team of lecture demonstrators. The format allows for and encourages interplay 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 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. Please note that this workshop is intended to expose as many demonstrations and ideas as possible to the participants. Since we will be doing approximately 100 demos during this workshop, time restraints DO NOT allow for extensive or in depth discussions of each demonstration. We will make every effort to answer all questions and concerns.

W34: Research-based Alternatives to Traditional Physics Problems

Sponsor: Committee on Research in Physics Education
Time: 8 a.m.–5 p.m. Sunday
Member Price: $80 **Non-Member Price:** $105
Location: STSS 117

Kathy Harper, Engineering Education Innovation Center, 244 Hitchcock Hall, 2070 Neil Ave., Columbus, OH 43210; harper.217@OSU.EDU

Thomas M. Foster, David P. Maloney

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

W35: Advanced Labs

Sponsor: Committee on Laboratories
Time: 1–5 p.m. Sunday
Member Price: $85 **Non-Member Price:** $110
Location: Tate 65

Jeremiah Williams, 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.

W36: Cosmology in the Classroom

Sponsor: Committee on Space Science and Astronomy
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 530B

Daniel Smith, South Carolina State University, 300 College St. NE, Orangeburg, SC 29115; dsmith@scsu.edu

Kim Coble

Recent observations, and advances in computation and visualization, have led to a revolution in our understanding of the structure, composition, and evolution of the universe. Experts should not be the only ones, however, who understand the physics and data that provide overwhelming evidence for Big Bang cosmology and its dark matter-dark energy extensions. In the first part of the workshop we will present (1) our research on common alternate student conceptions in cosmology, and (2) interactive web-based exercises from a curriculum that helps students to master the scientific concepts and processes leading to our current understanding of the universe. In the second part, we will present classroom-tested labs on the Large Scale Structure, featuring data from the Sloan Digital Sky Survey, as well as a Cosmic Microwave Background lab utilizing data from the Wilkinson Microwave Anisotropy Probe. Participants should bring their own laptops with spreadsheet software and Adobe Flash installed. (Supported by NSF PAARE, AST-0750814, and the South Carolina Space Grant Consortium/NASA EPSCor.)

W37: LEAP: Learner-Centered Environment for Algebra-based Physics*

Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 432A

Paula Engelhardt, Tennessee Technological University, 110 University Drive, Bruner Hall, Room 227, Cookeville, TN 38505; engelhar@tntech.edu

Steve Robinson

The Learner-Centered Environment for Algebra-based Physics (LEAP) is a newly developed, two-semester physics curriculum for algebra-based physics appropriate for both university and high school settings. The pedagogy and activity sequence is guided by research on student learning of physics and builds on the work of the NSF-supported project, Physics for Everyday

Thinking (PET). Students work in groups to develop their understanding of various physics phenomena including forces, energy, electricity and magnetism, light and optics. Students utilize hands-on experiments and computer simulations to provide evidence to support their conceptual understanding. Traditional problem solving is scaffolded by using the S.E.N.S.E. problem solving strategy. During this workshop, participants will be introduced to the LEAP curriculum and S.E.N.S.E. problem solving strategy, will examine and work through a sample of the types of activities students do including Java- and Flash-based simulations.

*Supported in part by NSF CCLI grant #DUE-0737324

W38: Improving Assessment in Your Courses Using Tools from the PER User's Guide

Sponsor: Committee on Educational Technologies
Co-sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price: $85**
Location: STSS 432B

Adrian Madsen, 1100 Chokecherry Ln., Longmont, CO 80503

Sarah McKagan, Eleanor Sayre

In this workshop, you will learn about new online resources to address the needs of faculty and department chairs around assessment, available on the PER User's Guide (http://perusersguide.org). We expedite your search for research-based assessments by providing access and guides to specific assessments such as concept inventories, beliefs surveys, upper division assessments, and rubrics for measuring scientific skills. We include information about the background, validation, and guidelines for administration of assessments. To gauge how your students' scores compared to those at peer institutions, we provide a national database of research-based assessment scores. You can upload your students' assessment scores and compare to other students like yours, visualize your data, and view statistics. You will receive a report of your results and suggestions on how to improve. These reports can be used to improve your teaching, make a case for more resources, and for your tenure and promotion file.

W39: Strategies to Help Women Succeed in Physics-related Professions

Sponsor: Committee on Women in Physics
Co-sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price: $85**
Location: STSS 121

Chandralekha Singh, 221 A Allen Hall, Department of Physics, University of Pittsburgh, Pittsburgh, PA 15213; 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.

W40: Research-based Materials for a New Introductory Quantum Mechanics Curriculum

Sponsor: Committee on Physics in Undergraduate Education
Co-sponsor: Committee on International Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price: $85**
Location: STSS 330

Antje Kohnle, School of Physics and Astronomy, University of St. Andrews, The North Haugh, St. Andrews, KY16 9SS, United Kingdom; ak81@st-andrews.ac.uk

Charles Baily, Derek Raine

The Institute of Physics New Quantum Curriculum (quantumphysics.iop.org, simulations also at www.st-andrews.ac.uk/physics/quvis) consists of freely available online texts and interactive simulations with accompanying activities for an introductory course in quantum mechanics starting from two-level systems. This approach immediately immerses students in quantum phenomena that have no classical analogue, using simpler mathematical tools that allow a greater focus on conceptual understanding. It allows from the start a discussion of interpretative aspects of quantum mechanics and quantum information theory. This workshop will give participants an overview of the new curriculum and supporting materials for instructors (simulations, interactive engagement materials and texts), along with the opportunity to explore them in greater depth according to their individual interests. We will describe our iterative process of refining the simulations and activities, and give examples of in-class use and outcomes. Participants are encouraged to bring laptops. This work is supported by the UK Institute of Physics.

W41: Physics Mentoring Training

Canceled

Sponsor: Committee on Graduate Education in Physics
Co-sponsor: Committee on Diversity in Physics
Time: 1–5 p.m. Sunday
Member Price: $75 **Non-Member Price:** $100
Location: STSS 412

Renee Michelle Goertzen, American Physical Society, One Physics Ellipse, College Park, MD 20740-3844; goertzen@aps.org

Monica Plisch

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.

W42: Using, Modifying, and Building Internet Problem-solving Coaches for Your Students

Sponsor: Committee on Research in Physics Education
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 512B

Leon Hsu, Department of Postsecondary Teaching and Learning, University of Minnesota, Minneapolis, MN 55455; lhsu@UMN.EDU

Bijaya Aryal, Evan Frodermann, Ken Heller, Qing Ryan

This workshop will introduce participants to a software system for creating and modifying computer coaching programs designed to help students develop expertise in solving problems in introductory physics. The coaches, which are delivered via the web so that students can use them at their convenience, provide students with individualized guidance and feedback while practicing using an expert-like problem-solving framework to solve problems. In addition, the software system allows instructors, even those with no programming background, to modify the coaching programs to be compatible with their teaching methods. We will discuss the motivation behind and possible uses of the computer coaches, along with the process used to build and test them. Participants should bring their own laptops to access the coaches and try building their own.

W43: Using the MIT MOOC to Teach You & Your Class Better

Sponsor: Committee on Physics in Undergraduate Education
Co-sponsor: Committee on Women in Physics
Time: 1–5 p.m. Sunday
Member Price: $60 **Non-Member Price:** $85
Location: STSS 530A

David Pritchard, Massachusetts Institute of Technology, Room 26-241, Cambridge, MA 02139; dpritch@mit.edu

Raluca Teodorescu, Boris Korsunsky, ZhongZhou Chen and MIT RELATE group

8.MReV, Mechanics ReView is a free online course whose Modeling Applied to Problem Solving (MAPS) pedagogy improves problem-solving expertise. You can use its ~300 highly praised problems directly or as inspiration for your own problems, and/or recommend it as advanced placement preparation for your students. Three offerings of Mechanics ReView have benefited over 300 physics teachers and 1000 students. Graduates praise the problems, the MAPS pedagogy, the discussion forums, and the availability of CEU credits. Based on Hestenes' seminal papers about modeling, MAPS generates problem-solving skills that transfer to a subsequent E&M course and helps students develop more expert-like attitudes towards science, particularly in problem-solving self confidence. The workshop will include innovative problem-solving and classification activities and discussions. Bring your laptop for a hands-on introduction to our MOOC. We seek users/collaborators for our materials, which can be freely modified. We acknowledge support by NSF, Google, and MIT.

W44: SCALE-UP 1

Sponsor: Committee on Research in Physics Education
Co-sponsor: Committee on Physics in Undergraduate Education
Time: 1–5 p.m. Sunday
Member Price: $65 **Non-Member Price:** $90
Location: STSS 312

Brandon Lunk; brlunk@ncsu.edu

Jon Gaffney

The Student Centered Active Learning Environment using Upside-down Pedagogies (SCALE-UP) project promotes both a style of classroom environment and a set of pedagogical strategies that together integrate the intimacy of small, discussion-based classrooms and laboratories even in large-enrollment introductory service courses. A successful SCALE-UP classroom is an active place, with round tables, whiteboards, and a pedagogy that encourages student collaboration. The actual design of such a classroom depends on class size, the institutional culture, and the needs of the faculty and students, but always the focus is on fostering relationships between students, faculty, and curricular materials. In this workshop, participants will learn about the philosophy of SCALE-UP, including how to use sample pedagogy, by working through a few of the same activities we give to our students. For more advanced topics, including curricular design, contact the workshop organizers.

W45: Physics and Toys II: Energy, Momentum, Electricity, and Magnetism Scheduling

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: STSS 420B

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. The workshop will concentrate on toys that illustrate the concepts of kinetic and potential energy, linear and angular momentum, electricity, magnetism, pressure, temperature and properties of materials. You will have the opportunity to participate in both qualitative and quantitative investigations using 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 be used for informal presentations to public groups of all ages, whether children or adults.

W46: Physics Union Mathematics PUM): Bringing Science and Engineering Practices to Your Classroom

Sponsor: Committee on Teacher Preparation
Co-sponsor: Committee on Physics in High Schools
Time: 1–5 p.m. Sunday
Member Price: $64 **Non-Member Price:** $89
Location: STSS 420A

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

Eugenia Etkina, 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. 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 and Engineering 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. Please bring a laptop with Quicktime if you have one.

Session & Workshop Sponsors List

AAPT Committee

Apparatus: TOP02, W03, W04, W12, W16, W33, AC, BC, EE, FE

Educational Technologies: T02, W02, W04, W08, W16, W23, W30, W32, W38, BA, CA, CK, DH, EA, EG, EI, FA, GC, TOP05

Graduate Education: W39, AG, CH, FB, TOP06,

High Schools: W10, W15, W19, W26, W27, W29, W46, BG, BJ, CD, CJ, TOP01,

History & Philosophy of Physics: W01, W14, AB, DF, EH

International Physics Education: W18, W40, CA, DC, FG, TOP11

Laboratories: W03, W13, W20, W35, AD, DE, DH, FE

Diversity: W18, AG, BH

Pre-High School Education: W24, W25, W45, BF, DK,

Professional Concerns: W24, CH, FB, TOP04, TO09

Research in Physics Education: W25, W30, W31, W32, W34, W37, W38, W42, W44, AE, AH, BG, CB, CE, CK, DC, DD, DJ, EG, TOP04, TOP06

Science Education for the Public: W09, PST2A, W22, W45, BF, CF, TOP03, TOP09

Space Science and Astronomy: W22, W28, W36, FG, TOP08

Teacher Preparation: W10, W46, BH, CG, DB, EC, FI

Two-Year Colleges: W09, W11, BI, BK, DI, GD

Undergraduate Education: W02, W08, W11, W40, W43, W44, AD, AE, AH, BD, CC, CE, DA, DD, EB, EF, FH, SPS Posters

Women in Physics: W39, W43, FJ, TOP11

2014 AAPT SUMMER MEETING SOCIAL MEDIA

#AAPTSM14

follow us on twitter

Follow us on Instagram

@AAPTHQ

Session SPS: SPS Undergraduate and Graduate Outreach Poster Session

Location: Coffman Union ground floor
Sponsor: Committee on Physics in Undergraduate Education
Date: Sunday, July 27
Time: 8–10 p.m.

Presider: Toni Sauncy

SPS01: 8-10 p.m. Brazil Nut Effect in the Binary Granular System

Poster –Yaran Li, Southeast University, Jiulong Lake Campus, Southeast University Nanjing, Jiangsu 211189, China; yaran_li@126.com

Yue Yu, Yue Gao, Southeast University

Larger particles often end up on the surface of the binary granular system when the container is shaken, which is the so called Brazil nut effect. We carry out the experiment by controlling vibration frequency and amplitude. Not only do we observe the Brazil nut effect, but we also reverse the Brazil nut effect, sandwich layered, and even some other configurations. The relations between vibration frequency, amplitude, and separated configurations are found, and we find that the factor of air plays an important role in this system.

SPS02: 8–10 p.m. Comparing Alternate Approaches to Spacetime Diagrams: The Loedel Diagram

Poster – Tobias A. Nelson, University of Wisconsin La Crosse, 1725 State St., La Crosse, WI 54601; nelson.tobi@uwlax.edu*

Roberto Salgado, University of Wisconsin La Crosse

As part of a systematic survey of the various methods for drawing spacetime diagrams for special relativity, we present the Loedel diagram and its advantages and disadvantages compared to the traditional Minkowski diagram.

1. E. Loede, "Geometric representation of the Lorentz Transformation," *Am.. J. Phys.* **25,** 327 (May 1957.)

*Sponsored by Roberto Salgado.

SPS03: 8–10 p.m. Energy Loss in Maxwell Rolling Pendulum System

Poster – Jixuan Hou, Southeast University, Department of Physics, Southeast University Nanjing, Jiangsu 211189, China; jixuanhou@hotmail.com

Jing Ji, Southeast University

We have analyzed the dynamics of an ideal Maxwell rolling pendulum system and semi-quantitatively demonstrated the energy loss cased by different physical mechanisms. By measuring the variance of the maximum height that the pendulum can reach each time, we conclude that air friction is not the primary cause of energy loss in the system, and the energy transfer to the swing pendulum motion might be the main reason of the energy loss.

SPS04: 8–10 p.m. Laminar Fluid Flow In Non-Circular Pipes

Poster – Michael J. Yohn, 824 Menomonie St., Eau Claire, WI 54703; yohnmj@uwec.edu*

The properties of laminar fluid flow have been well understood in the context of circular pipes for years. These properties, however, have not been well researched or compared to identical properties for pipes of a non-circular shape. These comparisons have applications for space saving and efficiency increases in architecture, engineering, and even medicine. Half pipes of a circle, square, and triangle with uniform cross-sectional surface area were constructed with PVC piping and sheeting, and filled with corn syrup. Aluminum foil squares were suspended in the corn syrup and their movements were observed. The flowing syrup was captured in digital video and then run through video analysis in LoggerPro to determine flow rates for various points. This analysis allows for fluid and energy transfer determinations and comparisons between the differently shaped pipes to be made, allowing for analysis of pipe shape efficiency as a whole.

*Sponsored by Matthew Evans

Sunday, July 27 Highlights

AAPT Workshops

REGISTRATION	7 a.m.–4 p.m.	Coffman ground floor
H.S. Physics Photo Contest Viewing and Voting		Coffman ground floor
Publications Committee	8–10 a.m.	Coffman Union 303
Meetings Committee	8–10:15 a.m.	Coffman Mississippi
Programs Committee I	5:30–6:30 p.m.	STSS 330
Section Representatives	5:30–8 p.m.	STSS 220
H.S. Share-a-Thon	6–8 p.m.	Tate Lab 133

Committee Meetings, 6:30–8 p.m.

–PIRA Committee	STSS 512A
–Teacher Preparation	STSS 420B
–Undergrad. Education	STSS 432B
–Women in Physics	STSS 432A
–Interest of Seniors	STSS 131B

REGISTRATION 7:30–9 p.m. Coffman ground floor

Exhibit Hall Opens / Welcome Reception

8–10 p.m.	Coffman Union Great Hall
–PIRA Resource Room	Coffman Great Hall Annex
–TYC Resource Room	Coffman ground floor

SPS Undergraduate Research and Outreach Poster Session and Reception

8–10 p.m. Coffman Union ground floor

SPS06: 8–10 p.m. On the Equilibrium Condition for the Movable Piston

Poster – Jing Ji, Southeast University, Nanjing, Jiangsu 211189 China; 101010411@seu.edu.cn

Jixuan Hou, Southeast University

It is not a sufficient equilibrium condition that the pressures are equal on both sides of a smooth adiabatic movable piston. We consider a system consisting of gas (with ideal gas model) which is partitioned into two parts by an adiabatic movable piston. From the microscopic point of view, even if the two parts are with equal pressures but different temperatures, energy can still transfer from higher temperature gas to lower temperature gas through the piston vibration, which is difficult to observe in macroscopic system but very significant in mesoscopic system.

SPS07: 8–10 p.m. On the Resonance of the Air Column in a Bottle

Poster – Yuchen Yang, Southeast University, Jiulong Lake Campus, Southeast Campus, Nanjing, Jiangsu 211189, China; yycdx@hotmail.com

Yiru Lv, Chunxuan Hu, Southeast University

When pouring water into a thermos, a sound with rising frequency appears. We recorded and analyzed the sound wave. By using spectrum analysis, we found that the sound exists in several different modes. After comparing the standing wave theory with our measurements, we found that they coincide with each other quite well. Our research shows that the frequencies of the sound are also affected by penetrability and diffraction.

SPS08: 8–10 p.m. The Minimum Force Required to Separate Two Alternating Books

Poster – Xudong Wu, Southeast University, Jiulong Lake Campus, Southeast University Nanjing, Jiangsu 211189, China; wxd19950902@foxmail.com

Yi Wang, Zi Liao, Mengdi Cao, Southeast University

It is difficult to separate two books with their pages overlapping alternately with each other. To research the minimum force required to separate these two alternating books, a dynamometer is used to measure the different friction for different distances between overlapping line and spine L. We found that the relation between maximum static friction and L shows a power law, which coincides our scaling argument.

SPS09: 8–10 p.m. The Research of the Linear Oscillator

Poster – Cheng Chi, Southeast University, Jiulong Lake Campus, Southeast University Nanjing, Jiangsu 211189, China; 272102647@qq.com

The bizarre behavior of a type of nonlinear oscillator confused many people. By analyzing the mechanical properties of a coil spring, we found the equivalent of the nonlinear oscillator, a linear two-mode spring system. By analyzing this linear model, we found that its solution can fit the experimental data collected from the nonlinear oscillator, which means that the motion of the nonlinear oscillator is linear indeed.

SPS10: 8–10 p.m. The Motion of a Falling Chain

Poster – Haoliang Su, Southeast University, Nanjing Jiulong Lake Campus, Nanjing, Jiangsu 211189; China suhl06@126.com

Kai Wang, Yuzhao Yang, Southeast University

We assembled an experimental apparatus using a chain that is initially attached by its two ends at the same height. We observed that, as one of the ends is released, the acceleration of the chain tip is greater than the acceleration of gravity. We posed our mechanical model which can fit the experimental data very well.

SPS11: 8–10 p.m. Measurement of Planck's Constant and Plane Separation for NaCl Monocrystal

Poster – Misganaw Getaneh, University of Tennessee at Martin,115 Stephenson Rd., Martin, TN 38237; mgetaneh@utm.edu

Jordan Johnson, University of Tennessee at Martin

Diffraction of X-rays scattered by a NaCl monocrystal was used to measure the spacing between two adjacent planes in a NaCl monocrystal and also Planck's constant. The x-rays were produced through bremsstrahlung and K_α, K_β transitions when high-energy electrons were stopped by a Molybdenum target. The first three orders of constructive interference of the scattered K_α, K_β lines were analyzed to determine the separation d of two adjacent planes of NaCl in the [1,0,0] direction. The crystal plane spacing, according to this measurement is d=281±4 pm and the corresponding edge length of a unit cell of NaCl is a_0=562±8 pm. These are reasonably close to the literature values of d=282.01 pm and a_0=564.02 pm, respectively. Data of count rate versus scattering angle was obtained for various accelerating voltages for the bremsstrahlung part of the x-ray spectra. Analysis that is based on the displacement of the high energy edge of the x-ray spectra with increase in the accelerating voltage and the Duane-Hunt law were used to determine Planck's constant h. Planck's constant is measured to have the value $h=(6.8\pm0.2)\times10^{(-34)}$ Js, which is close to the literature value of $h=6.63\times 10^{(-34)}$ Js.

SPS12: 8–10 p.m. Space Balloon: Journey into the Stratosphere

Poster – Carlos Blanco, Purdue University, Department of Physics, West Lafayette, IN 47907; kelley28@purdue.edu*

Danielle Harper, Patrick A. Kelley, Cordero Magana, Vatsal Purohit, Purdue University

Purdue University's Society of Physics Students (SPS) conducted an investigation of the Earth's atmosphere by launching space balloons during the spring 2014 semester. The experiment utilized a balloon that would carry a 4-6 lb. payload. This payload consisted of a GPS detector, radio transmitter and two cameras to observe both the Earth's surface and also to detect Baryons. Additional sensors attached to the weather shield of the balloon collected data on: altitude, pressure, humidity and ambient light. The space balloon was launched on two separate occasions to reach a height of over 80,000 ft. or greater than 15 miles (~ 25 Km) and traveled over 60 miles before parachuting to the Earth. Data on each variable collected as a function of altitude and position will be presented along with pictures from the flight.

*Sponsored by A. Hirsch, Purdue University

SPS13: 8–10 p.m. Concentration-dependent Luminescent of GdF3: Yb3+, Er3+

Poster – Chufeng Liu, Sun Yat-Sen University, No. 135 West Xingang Road, Guangzhou City, Guangzhou, Guangdong 510275, China; 444394693@qq.com*

Jiawei Yan, Sun Yat-Sen University

Yb3+, Er3+ co-doped rare-earth fluorides have attracted great attention due to their excellent upconversion luminescent properties and research on Yb3+, Er3+ co-doped GdF3 nanocrystals are also flourishing. However, concentration effects of Yb3+ and Er3+ on luminescent properties were seldom studied. In this paper, a series of GdF3:20% Yb3+,x% Er3+ (x = 1, 2, 3, 5) and GdF3:y%Yb3+,2%Er3+ (y = 10, 20, 40, 60, 98) nanoparticles (NPs) were prepared by a hydrothermal method. The structural properties of the products were characterized by X-ray diffraction, scanning electronic microscopy and transmission electron microscopy. . Luminescence spectra under 980 nm and 390 nm excitation of GdF3:y% Yb3+,Er3+ NPs show that RGR is positively proportional to the Yb3+ concentration. The corresponding energy transfer mechanisms were illustrated. The results show that GdF3:Yb3+,Er3+ NPs are promising materials in photovoltaic, display panel and bio-imaging.

*Sponsored by Fuli Zhao

SPS14: 8–10 p.m. Electrochromic Device Based on Core-Shell Au-Ag Plasmonic Nanoparticle Array

Poster – Ziying Feng, Sun Yat-Sen University, No.135 West Xingang Road, Guangzhou, Guangdong 510275, China; jiangchensysu@gmail.com*

Chen Jiang, Yang He, Sun Yat-Sen University

Plasmonic effect in Au-Ag nanostructures was utilized to realize novel electrochromic materials. Quasi ordered Au-Ag core-shell nanoparticle array has been fabricated by thermal evaporation deposition of Au and electrochemical deposition of Ag onto SiO2 hole array, which is prepared with the assistance of reactive ion etching and anodic aluminium oxide template. The thickness of the Ag shell could change by alternating the electrochemical deposition time, and therefore tunability of the absorption spectrum as well as a prototype plasmonic electrochromic device were achieved.
*Sponsored by Fuli Zhao

SPS15: 8–10 p.m. Sympathetic Cooling of Antiproton

Poster – Lu Wang, Sun Yat-Sen University, No. 135 West Xingang Road, Guangzhou, Guangdong 510275, China; lu.wangphysics@gmail.com*

This thesis describes the laser sympathetic cooling of the antiproton in AEgIS experiment. The antiproton and buffer gas particles are trapped in paul trap. We use Matlab, Mathematica and COMSOL to achieve the simulation.
*Sponsored by Fuli Zhao

SPS16: 8–10 p.m. Stability of FeCl3-graphite Intercalation Compounds Under Uniaxial Pressure

Poster – Ziling Deng, Sun Yat-Sen University, No. 135 West Xingang Road, Guangzhou City, Guangzhou, Guangdong 510275, China; nanally@qq.com

Longfei Li, Sun Yat-Sen University

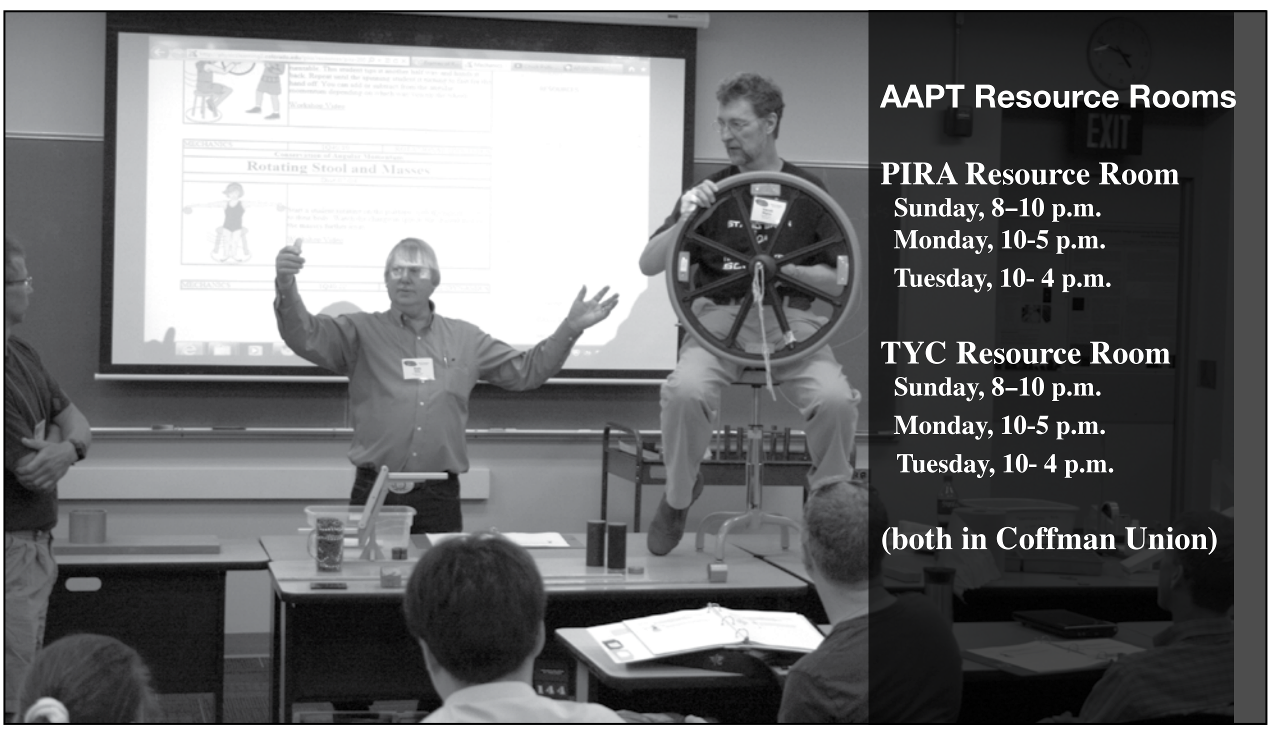
We report the stability of pure stage-1 FeCl3-graphite intercalation compounds (FeCl3-GICs) under uniaxial pressure by examining changes in X-ray diffraction patterns. It is found that FeCl3-GIC remains stable when exposed to an uniaxial pressure below 528 Mpa. However, they become unstable and deintercalate under a higher uniaxial pressure, and can even change into other stages. The time the pressure is applied has no significant effect on the structure of FeCl3-GICs.
*Sponsored by Fuli Zhao

First Timers' Gathering

Learn more about **AAPT** and the Summer Meeting

High School Physics Teachers Day attendees are encouraged to check in at this event!

Monday, July 28
7–8:30 a.m.
Coffman Union - Mississippi



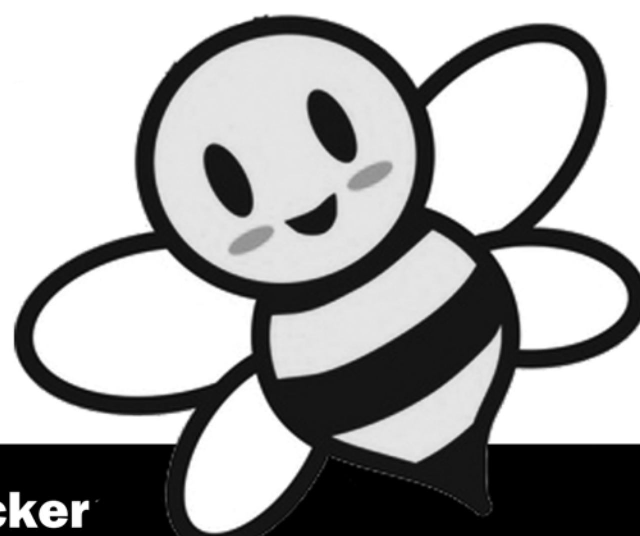
AAPT Welcomes First Time Attendees

New this year, we've come up with a creative way to help identify First Timers! Come and check out the latest buzz and meet other newbies at the "Bee Hive" aka the First Timers' Gathering on **Monday, July 28 from 7:00 - 8:30 AM.**

This is the best time to learn about AAPT and the Summer Meeting, as well as meet fellow attendees. AAPT leadership will be represented to discuss ways to get more involved with AAPT. You are also welcome to participate in any of AAPT's Area Committee meetings.

Not sure who's new?
Rest assured you'll be able to easily spot other FTAs (First Time Attendees), from the "newbie/bee" stickers on their badges. Make sure to grab one at the registration desk!

Calling all our 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

Session AA: High School Topics

Location: STSS 220
Sponsor: AAPT
Date: Monday, July 28
Time: 8:30–9:50 a.m.

Presider: Peter Bohacek

AA01: 8:30-8:40 a.m. There Goes AP Physics B, Here Comes AP Physics 1 & 2

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

The long anticipated change in the AP algebra-based physics course occurs this fall. This paper will address some of the differences in style and content of assessment questions on the new AP Physics 1 and AP Physics 2 exams, and highlight some of the resources that are available from the College Board in preparation for the new courses.

AA02: 8:40-8:50 a.m. Implementing Inquiry-based Investigations in the AP Physics 1 and AP Physics 2 Courses

Contributed – Martha Lietz, 2659 Hillside Lane, Evanston, IL 60201-4933; marlie@d219.org

This talk will provide insight on how inquiry-based investigations support the understanding of the AP Science Practices. This talk will also highlight samples of the teacher support materials, such as the new inquiry-based laboratory guide, that are available to facilitate the transition to the instructional strategies that will support student success. This talk will also highlight sample questions of how the science practices will be assessed on the new exams.

AA03: 8:50-9 a.m. Contributing to the Development of NGSS-based Large-Scale Assessments

Contributed – Thomas J. Regan, The College Board, 11955 Democracy Drive, Reston, VA 20190; tregan@collegeboard.org

States are now considering adopting the Next Generation Science Standards (NGSS). Physics educators can help ensure the quality of the physics components of any ensuing large-scale assessments. To this end, leverage points (RFI, RFP, Scope of Work, Test Specifications, Item Specifications, Committees) of typical large-scale assessment programs will be identified. For each leverage point, strategies for incorporating the NGSS' strengths, and compensating for the NGSS' weaknesses, will be presented. Goals for the assessment will be presenting correct content, engaging the student in meaningful tasks, obtaining useful information, and transparency.

AA04: 9-9:10 a.m. Computer Coaches in Problem Solving: Evaluation by High School Teachers

Contributed – Andrew J. Mason, University of Central Arkansas, Lewis Science Center, 171 Conway, AR 72035-0001; ajmason@uca.edu

Mishal Benson, University of Central Arkansas

At the University of Central Arkansas we are investigating ways to integrate web-based computer coaches for problem solving into high school physics classes. The programs are designed to provide students with coaching in decision-making processes necessary for using an expert-like framework to solve physics problems and were originally developed at the University of Minnesota, Twin Cities for university calculus-based introductory physics classes. We have modified a set of the programs to be used in algebra-based high school physics classes. During the summer and fall of 2013, we recorded written and spoken artifacts from nine high school physics teachers who evaluated the utility of the modified coaches both for the classroom and for teacher-training purposes. We categorize their statements and compare their implementations that of the original calculus-based coaches for university level courses. This work was partially supported by NSF DUE-0715615.

Monday, July 28 Highlights

High School Physics Teachers Day

REGISTRATION 7 a.m.–5 p.m. Coffman Union ground floor

First Timers' Gathering 7–8:30 a.m. Coffman Union Mississippi

Spouses' Boat Tour 12–1:30 p.m. offsite

PIRA Resource Room Coffman Union Great Hall Annex

TYC Resource Room Coffman Union ground floor

Apparatus Competition Coffman Union Great Hall Annex

Kindle Fire Raffle 10:15 a.m. Coffman Union Great Hall

H.S. Physics Photo Contest Viewing and Voting Coffman Union ground floor

TEACHING AWARDS, DSCs 10:30–12 Northrop Auditorium

COMMITTEE MEETINGS, 7–8:30 a.m.

–Diversity in Physics	STSS 420B
–Educational Technologies	STSS 432A
–Graduate Education in Physics	STSS 432B
–Science Education for the Public	STSS 131B

Early Career Professionals Speed Networking 12–1:30 p.m. Coffman Union President's

High School Luncheon 12–1:30 p.m. Coffman Union Mississippi

COMMERCIAL WORKSHOPS

–PASCO	12–1 p.m.	STSS 131B
–eScience Labs LLC	12–1 p.m.	STSS 530A
–Perimeter Institute	12–1 p.m.	STSS 131A
–Eugenia Etkina	12–1 p.m.	STSS 210
–Perimeter Institute	1:30–2:30 p.m.	STSS 131A

AmEx Card Raffle 3:45 p.m. Coffman Union Great Hall

COMMITTEE MEETINGS, 6–7:30 p.m.

–Apparatus	STSS 420B
–Physics in High Schools	STSS 312
–International Physics Education	STSS 432A
–Professional Concerns	STSS 432B
–Space Science and Astronomy	STSS 131B

SPS Undergraduate Awards Reception
6–7:30 p.m. Coffman Union Mississippi

PLENARY: Physicist James Kakalios
7:30–8:30 p.m. Northrop Auditorium

AAPT Fellows Reception 8:30–9:30 p.m. Northrop Auditorium

ALphA Committee 8:30–10 p.m. Coffman Union 323

Poster Session I 8:30–10 p.m. Coffman Union ground floor

AA05: 9:10-9:20 a.m. Improving Secondary Physics Through Morehead State's Early College Program

Contributed – Kent J. Price, Morehead State University, Department of Physics, Morehead, KY 40351; k.price@moreheadstate.edu

Many secondary schools in Eastern Kentucky do not have the resources or personnel to offer a rigorous high school physics course. Some of those that do have little communication with university science departments. The result is that secondary students in the region wishing to pursue a degree in science or engineering will be less prepared for college. This presentation will provide an overview of two different strategies to improve high school physics instruction in the region, both through Morehead State's Early College program. One involves university physics faculty serving as mentor to a qualified high school teacher in the region. The relationship has resulted in significant student improvement on such measures as the Force Concepts Inventory and better alignment of the high school physics curriculum with university expectations. The other collaboration involves live internet-based instruction from college faculty to bring physics to a school system without a local physics instructor. Morehead State's Early College Physics program will be described, along with the advantages and disadvantages of the two different collaborations.

AA06: 9:20-9:30 a.m. Multiple Representations in Modeling Instruction and Literacy Obsessed Administrators

Contributed – Igor V. Proleiko, Carhahan High School of The Future, 4041 S. Broadway, St. Louis, MO 63118; Igor.proleiko@slps.org

Modeling Instruction uses multiple representations for the models, verbal description being one of the representations. Capitalizing on the verbal representation, the techniques of translating words into other representations, and other representations into words are discussed. The method allows to keep the administrators who have constant obsession with the "literacy" off your back while not sacrificing instruction time.

AA07: 9:30-9:40 a.m. Implementing and Using Standards-based Grading for Learning

Contributed – Bradley J. Wysocki, Bloomer High School, 1310 17th Ave., Bloomer, WI 54724; bwysocki@bloomer.k12.wi.us

Learn how to make the change to grading based on what students know, not how many points they earn. It's not as hard as you think! This talk will guide participants through the process of making the grading shift. Standards-based grading (SBG) is designed to assess students on a defined set of standards for the course. I've successfully implemented a SBG system in my high school physics and chemistry courses. The ideas of SBG can easily be related to any type of course. I will show you just how easy it is along with the tools available to help you get started. Some of my struggles and challenges will also be shared, however overall the change has been very positive!

AA08: 9:40-9:50 a.m. Physics First – The app

Contributed – Meera Chandrasekhar, University of Missouri, 416 Physics Building, Columbia, MO 65211; meerac@missouri.edu

Dorina Kosztin, University of Missouri

Mark Salata, Werkz Publishing, Inc

Want your students to have fun learning physics? Here's the Physics First app for teaching physics in ninth grade. For the past eight years our group has developed curriculum for teaching physics in ninth grade (Physics First). This curriculum was used to conduct professional development for ninth-grade science teachers to teach a yearlong course in physics (A TIME for Physics First). This curriculum, which is based on inquiry and modeling, has been transformed into an app that can be used on iOS, Android, or on a computer. In this app, students interact with the content by writing explanations, drawing diagrams and graphs, submitting their work for grading, and receiving feedback from their teachers. The app will be demonstrated during the presentation.

Session AB: Historical Perspectives on Teaching Physics

Location: STSS 330
Sponsor: Committee on History and Philosophy in Physics
Co-Sponsor: Committee on the Interests of Senior Physicists
Date: Monday, July 28
Time: 8:30–10 a.m.

Presider: Bonnie Gidzak

AB01: 8:3-9 a.m. Van Vleck Teaching Quantum Theory in the Midwest 1924/34

Invited – Michel Janssen, University of Minnesota, Tate Lab of Physics, Minneapolis, MN 55455; janss011@umn.edu

In this talk, I examine to what extent some general observations of Thomas S. Kuhn about the effects of scientific revolutions on textbooks and teaching are borne out by two books and a course on quantum theory by Kuhn's own PhD adviser, the American theoretical physicist and Nobel laureate John H. Van Vleck. The two books are Van Vleck's *Bulletin for the National Research Council* (NRC) on the old quantum theory published in 1926, right after the quantum revolution, and his famous book on susceptibilities of 1932. Student notes for two editions of Van Vleck's graduate course on quantum mechanics survive, one for the 1927/28 edition in Minneapolis, one for the 1930/31 edition in Madison. These materials, I argue, suggest that there is much more continuity in the quantum revolution than Kuhn's picture of paradigm shifts allows for.

AB02: 9-9:30 a.m. Gearing Up to Learn Electromagnetism

Invited – Cameron Lazaroff-Puck, University of Minnesota, Minneapolis, MN 55455-0213; lazar114@umn.edu

In this talk, I will cover the importance of mechanical analogy in teaching and developing theories of electromagnetism in the late 19th century at Cambridge University. In 1862 and 1865 James Clerk Maxwell published two seminal papers on electromagnetism both founded on physical analogies to simple machines designed by Maxwell himself. Maxwell's role as the first head of the Cavendish Laboratory, founded in 1874 as a teaching laboratory, provided him the opportunity to introduce these simple machines as teaching aides for a new generation of physicists learning his theory of electromagnetism. Editors of Maxwell's *Treatise on Electricity and Magnetism* made a similar choice, reintroducing mechanical analogy to the readers of his textbook. I contend that mechanical analogies were not only a crucial tool in Maxwell's individual quest to construct a theory of electromagnetism, but that they were also intended to help future students grasp the obscure electromagnetic relations that Maxwell had built on top of these mechanical foundations.

AB03: 9:30-10 a.m. Using History to Teach the Atom, 1945-1958

Invited – Bonnie Gidzak, University of Minnesota, Minneapolis, MN 55414; baue0189@umn.edu

One approach to introducing atomic structure and processes is teaching the history of the discoveries. In contrast to the teaching of other physics concepts, this may seem simply like a convenient place to insert a history lesson to, for example, meet state education standards. However, in the early atomic age following World War II, the use of history played specific roles in atomic science high school and public education. Educators, scientists, and journalists used this historical approach to the atom in the late 1940s through 1950s because this view was seen as approachable, understandable, and less technical. Additionally, some educators and scientists used the historical approach in an effort to separate the science of the atom from the weapon of the atomic bomb. Drawing on curricular materials, popular media, professional education journals and select archival documents, my talk will examine the use and implications of the historical approach in atomic science education.

Spouses/Guest Gathering

Mississippi Queen Paddle Boat Tour!

Meet in Coffman Union near Registration

Monday, July 28
12 - 1:30 p.m.

Session AC: Creating Research-Like Experiences for All Students

Location: STSS 114
Sponsor: Committee on Apparatus
Date: Monday, July 28
Time: 8:30–10 a.m.

Presider: Ben Zwickl

AC01: 8:30-9 a.m. Undergrad Students Do Authentic Research by Writing a Research Proposal

Invited – Susan Wick, University of Minnesota, Minneapolis, MN 55414; swick@umn.edu

Undergraduate STEM students can experience many elements of authentic research without setting foot in a lab. I will describe the genetic engineering proposal project that students do in the first semester of the Foundations of Biology course at the University of Minnesota and suggest how this approach could likewise be used in physics courses. A major goal is to provide them with the opportunity to do the work of the field, not just read about it. Our approach requires teams of students to identify a problem that could be solved with application of STEM approaches, and to integrate many elements of their coursework to propose a solution to the problem in both a written proposal and in a conference-style poster. With scaffolding and detailed rubrics for all stages of the project, students are capable of high-level work that gives them a glimpse of the creative aspects of doing science.

AC02: 9:-9:30 a.m. From Replicating Eratosthenes to Cavendish – A Capstone Project for All

Invited – Robert Hobbs, Bellevue College, Bellevue, WA 98007; rhobbs@bellevuecollege.edu

For nearly 30 years Bellevue College has employed a capstone lab project in the last quarter of the first year calculus-based physics sequence. This assignment can provide many of the attributes of an undergraduate research experience and may be scalable/adaptable to a variety of institutions. Students confront design, fabrication, and measurement issues around an experimental question not addressed by labs in any part of the rest of the sequence. The current assignment requires them to improve the experiment informed by an analysis of preliminary results. Students must present their results to their peers accompanied by artifacts from the experiment. These artifacts often become part of our lecture demonstration equipment collection. Students perform part of the assessment of both their own teammates and other teams. History, our motivation, assessment, resource requirements—both material and human, benefits, and problems will be addressed in the talk. See http://scidiv.bellevuecollege.edu/physics/hobbs/capstone/

AC03: 9:30-10 a.m. Undergraduate Research Projects in UK Universities

Invited – Ross K. Galloway, University of Edinburgh, School of Physics and Astronomy, Edinburgh, Midlothian EH9 3JZ, UK; ross.galloway@ed.ac.uk

Essentially all undergraduate physics degree programs in the UK require every student to complete a substantial research project, usually in the final year of the program. Students typically conduct this project while embedded within one of the physics research groups of their institutions. Project lengths vary but usually encompass 200-600 hours of work, and there is an expectation that the project should feature original research. I will discuss the nature of these research projects, highlighting features such as project topic allocation, pre-project preparation, assessment, and the student skills developed by the project work. I will discuss the strengths and also the challenges of this system, and give some examples of student project topics from my own institution.

Session AD: Physics in a Biological Context

Location: STSS 412
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Laboratories
Date: Monday, July 28
Time: 8:30–9:30 a.m.

Presider: Nancy Beverly

AD01: 8:30-9 a.m. A Summary from Three Opportunities to Explore the Intersection of Biology and Physics: Research and Education

Invited – Mel Sabella, Chicago State University, Chem/Phys, Chicago, IL 60628; msabella@csu.edu

Physics in a biological context has been part of the physics education discussion for some time, with focused sessions at AAPT Meetings, efforts to reform the algebra-based physics course, and textbooks that attempt to meet the needs of biology students. This effort has grown tremendously in recent years. Examining how our physics courses are and are not meeting the needs of biology students and whether these classes are capitalizing on the exciting physics in biological applications will be front and center this year, with three opportunities for the biology and physics communities, as well as the research and education communities, to engage in this ongoing discussion. In this talk we highlight some of the major contributions from the March Introductory Physics for the Life Sciences Conference, the June Gordon Research Conference: Physics Research and Education, and the summer theme issue of the *American Journal of Physics*, as these events serve as guides to exploring these intersections.

AD02: 9-9:30 a.m. The 2014 Conference on Introductory Physics for the Life Sciences

Invited – Robert Hilborn, American Association of Physics Teachers, One Physics Ellipse, College Park, MD 20740-3845; rhilborn@aapt.org

In March 2014, the American Association of Physics Teachers, with support from the National Science Foundation, hosted a conference on Introductory Physics for the Life Sciences (IPLS). The conference was attended by about 180 participants with representatives from both the biology and physics communities. I will report on the conference and the resulting recommendations on many topics related to IPLS courses including labs for IPLS courses, articulating learning goals and objectives, designing courses for a wide range of life science students, what life scientists expect when their students take IPLS courses, and the politics of changing course content and enhancing IPLS courses with research-based instructional strategies.

Session AE: PER in Upper Division Physics

Location: STSS 230
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 28
Time: 8:30–10 a.m.

Presider: Mary Bridget Kustusch

AE01: 8:30–9 a.m. Student Framing Impacts Math/Physics Thinking in the Context of Matrix Multiplication

Invited – Warren M. Christensen, North Dakota State University, Fargo, ND 58102; Warren.Christensen@ndsu.edu

In principle, a student who has completed both linear algebra and quantum mechanics should have a wealth of conceptual and procedural knowledge that s/he has accrued from a wealth of mathematics and physics classes. However in practice, it seems that many students come into our physics courses lacking skills that we know were taught in mathematics courses. This investigation casts light on students' thinking about matrix multiplication and how student thinking appears to be influenced by their framing of the problem as either a mathematics or physics question. We use the framework of Framing and Resources to describe a single student's thinking during an interview. Using lexicon analysis, we find students seem to shift from a "mathematical frame" to a "physics frame" and back again, but struggle to successfully transfer concepts between those frames. I will highlight the markers for these frame shifts and the implications for future study.

AE02: 9-9:30 a.m. Conducting Research in Upper-Division Laboratory Courses*

Invited – MacKenzie R. Stetzer, University of Maine, Orono, ME 04469-5709; mackenzie.stetzer@maine.edu

The physics education research community has only recently begun to focus its attention on upper-division and advanced laboratory courses. These courses are often intended to help prepare undergraduates for experimental research at the undergraduate and graduate levels and for careers in industry. As a result, such courses are particularly rich environments in which to conduct research due to the many important goals of laboratory instruction at this level, which vary from course to course. I will use an ongoing investigation of student learning in junior-level analog electronics courses to illustrate the importance of aligning research questions with course learning goals and to highlight some of the challenges associated with conducting research in these types of courses.

*The work described has been supported in part by the National Science Foundation under Grant Nos. DUE-1323426, DUE-1022449, and DUE-0962805.

AE03: 9:30-10 a.m. Professional Development of Pre-service Physicists: Affordances and Constraints

Invited – Eleanor C. Sayre, Kansas State University, Manhattan, KS 66506; esayre@gmail.com

Paul W. Irving, Michigan State University

Research on upper-division students opens up exciting avenues into professional development for pre-service scientists. They learn so much more than book content: physics culture, research experiences, bench skills. Their participation is much more meaningful than mere classwork: they try on different identities, aspire to future physics selves, take on organizational responsibilities. Yet, research on upper-division students is not all sunshine and roses. In this talk, I discuss some of the affordances and constraints of research on upper-division students from the lenses of a few projects on their development as pre-service physicists. I may discuss how students build communities of practice in advanced laboratory, how students grow to view physics as a prospective professional field, and how we (as researchers) can tell.

Session AF: Teacher Training and Enhancement

Location: Tate Lab 131
Sponsor: AAPT
Date: Monday, July 28
Time: 8:30–9:40 a.m.

Presider: Brian Pyper

AF01: 8:30-8:40 a.m. Content Knowledge for Teaching Energy: Addressing Unexpected Moments

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

Eugenia Etkina, Rutgers University

Drew Gitomer

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). Specifically CKT addresses what teachers do (these activities are called tasks of teaching) and how their actions take into account students' prior knowledge and learning trajectories. One such task of teaching is dealing with unexpected ideas that students bring to the conversation and, therefore, unplanned moments in the classroom. In this talk, we will present two instances of teachers facing such unexpected moments in the classroom. We will then discuss how elements of Content Knowledge for Teaching and differences in teachers' CKT can be inferred from these moments through a combination of video analysis and analysis of the teacher's reflection on the moment.

AF02: 8:40-8:50 a.m. Preparing Irish Secondary Science Teachers for Inquiry-based Science Education

Contributed – Paul Grimes, Dublin City University, Glasnevin, Dublin, Ireland; paul.grimes3@mail.dcu.ie

Scott McDonald, Pennsylvania State University

Leanne Doughty, Paul van Kampen, Dublin City University

We have investigated Irish science teacher candidates' (TCs') views of inquiry-based science teaching (IBSE) through the lens of their experiences as science students. This study makes an inventory of the TCs' conceptions of IBSE. We describe a course designed to initiate re-enculturation to more appropriate ways of understanding IBSE: the teacher candidates engage in and critique a variety of inquiry-based activities. We report on the current culture of science teaching within the Irish school system and contrast it with the aims set out at policy level. We gain insight into the teacher candidates' ideas about IBSE and their cultural resistance to it. Specifically, we investigate what practices the TCs highlight as constituting IBSE and how they code the purpose of these practices. We describe how these practices and coded purposes reflect aspects of their professional pedagogical vision of IBSE.

AF03: 8:50-9 a.m. Physics and Everyday Thinking at Western Washington University

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

At Western Washington University, historically a teacher training college, pre-service elementary teachers take science content and methods courses in a multi-disciplinary Science, Math, and Technology Education program housed in the College of Science and Technology. Each year, ~200 prospective elementary teachers complete a 10-week physics course using Physics and Everyday Thinking (PET) [1]. The course is taught in multiple sections by faculty in physics, geology, and chemistry. Many students go on to take additional content courses in geology and biology that use curricula developed at WWU and modeled after PET. During these courses, written student data from quizzes, reflective writing assignments, and standardized assessments are routinely collected, providing a rich laboratory for investigations of student learning. This talk presents an overview of this thriving instructional program as well as brief examples of ongoing research.

1. F. Goldberg, S. Robinson, and V. Otero, *Physics and Everyday Thinking* (It's About Time, Armonk, NY, 2008).

AF04: 9-9:10 a.m. Integrating the Next Generation Science Standards into Professional Development*

Contributed – Jennifer L. Docktor, University of Wisconsin-La Crosse, La Crosse, WI 54601; jdocktor@uwlax.edu

Gubbi Sudhakaran, University of Wisconsin-La Crosse

Jerry Redman, Winona State University

The "A LOT of Science" project at the University of Wisconsin-La Crosse provides professional development (PD) in Physical Science to in-service elementary and middle school teachers from high-needs school districts during summer institutes and ongoing weekend workshops. The PD is designed to incorporate the Next Generation Science Standards into project activities. We will summarize findings from all three years of the project, including teacher gains in content knowledge, student achievement data, self-reported use of inquiry-based pedagogy, and additional impacts of the partnership.

*This project is funded by a U.S. Department of Education Mathematics and Science Partnerships Program grant through the Wisconsin Department of Public Instruction.

AF05: 9:10-9:20 a.m. Alliance for Physics Excellence – Addressing Alabama's H.S. Physics Teacher Needs

Contributed – James W. Harrell, University of Alabama, Department of Physics & Astronomy, Tuscaloosa, AL 35487-0324; jharrell@ua.edu

Dennis Sunal, University of Alabama

Jim Nelson, Jane Nelson, Santa Fe Community College

Marius Schamschula Alabama A&M University

The need for more qualified HS physics teachers in the U.S. has been well documented. In Alabama about 10% of practicing physics teachers has an academic major in physics and 25% of H.S. students are attending a school where physics is not offered. The Alliance for Physics Excellence (APEX) is a comprehensive NSF-MSP project designed to address this need by providing extensive professional development to 77 practicing physics teachers over a five-year period and scholarships for pre-service teachers. APEX is a partnership of institutions and agencies that provides professional development to enhance physics content knowledge and the skills to teach physics (physics PCK), and self-help activities such as classroom action research. APEX will have provided initial training to 44 teachers by summer 2014. This presentation will give an overview of the program and comprehensive baseline data on the classroom environment of these teachers.

AF06: 9:20-9:30 a.m. A Qualitative Study of NITARP's Impacts on Teachers' Science Teaching

Contributed – Debbie A. French, University of Wyoming/CAPER, Dept. 3374 Secondary Ed., Laramie, WY 82070; dfrench6@uwyo.edu

Timothy F. Slater, Andrea C. Burrows, University of Wyoming/CAPER

This qualitative study describes how the NASA/IPAC Teacher Archive Research Program (NITARP) changed teachers' thoughts about astronomy and what happened in their classrooms. Teachers reported increasing astronomy content knowledge, incorporating the use of real data, and implementing new skills, programs, and research into their curriculum. They also felt more confident in teaching how scientific research is conducted. The results of this exploratory study showing positive impacts motivate us to more deeply study the underlying mechanisms in this and similar programs best poised to improve science education. Direct quotes and other qualitative data from participants will be used as evidence to these findings. These findings will be compared to the results of similar RET programs.

AF07: 9:30-09:40 a.m. Training and Career Development of Physics Teaching Assistants

Contributed – Emily Alicea-Muñoz, Georgia Institute of Technology, School of Physics, Atlanta, GA 30332; ealicea@gatech.edu

Carol Subiño, Daegene Koh, Michael F. Schatz, Georgia Institute of Technology

In large introductory physics courses, Teaching Assistants (TAs) are the instructors with whom students most frequently interact. Consequently, it is essential that TAs receive appropriate training and preparation before they enter the classroom. In fall 2013, the School of Physics at Georgia Tech began preparing its new TAs through a training and mentoring program that covers pedagogy, physics classroom issues, and career development strategies. Here we discuss the elements of our pilot training program, its effects on TAs' attitudes about teaching, and the modifications and improvements we will be implementing for the next cycle of new TAs in fall 2014.

Session AG: The Impact of the GRE and Graduate Admissions on Diversity in Graduate School

Location: Tate Lab 133
Sponsor: Committee on Diversity in Physics
Co-Sponsor: Committee on Graduate Education in Physics
Date: Monday, July 28
Time: 8:30–10 a.m.

Presider: Kim Coble

AG01: 8:30-9 a.m. Using GRE Cut-off Scores Suppresses Diversity in Graduate Programs

Invited – Casey Miller, University of South Florida, Tampa, FL 33620; millercw@usf.edu

I will present data showing that significant performance disparities on the GRE Quantitative and GRE Physics Subject test exist based on the test taker's race and gender. Because of the belief that high GRE scores qualify one for graduate studies, the diversity issues faced by physics and all STEM fields may originate, at least in part, in misuse of the GRE scores by graduate admissions committees. I will quantitatively demonstrate this by showing that the combination of a hard cut-off and the different score distributions leads to the systematic underrepresentation of certain groups. I will present data from USF's PhD program that shows a lack of correlation between GRE scores and research ability; similar null results are emerging from numerous other programs. I will then discuss how assessing non-cognitive competencies in the selection process may be the key to an enlightened search for the next generation of scientists.

AG02: 9-9:30 a.m. Going Beyond Standardized Exam Scores in Graduate Admissions: Enhancing Diversity and Predicting Success

Invited – Rodolfo Montez, Vanderbilt University, Nashville, TN 37240; rodolfo.montez.jr@gmail.com

Keivan Stassun Vanderbilt University, Fisk University

We present the approach to graduate admissions developed by the Fisk-Vanderbilt Masters-to-PhD Bridge Program. The approach emphasizes a careful examination of applicants' basic academic preparedness together with noncognitive tracers of future success—so-called "grit" or "performance character"—and does not rely upon standardized exam scores such as GREs. This approach has enabled the Fisk-Vanderbilt program to identify and select large numbers of underrepresented minority students who are succeeding at the PhD level, making the program the nation's top producer of underrepresented minority PhDs in astronomy. We highlight outcomes of the program utilizing this "enlightened approach" to admissions, and share tools developed by the program for use by others.

AG03: 9:30-10 a.m. Comprehensive Graduate Admissions at Berkeley: Approaches and Outcomes

Invited – Colette E. Patt, UC Berkeley, 101 Durant Hall, Berkeley, CA 94720-2920; colette@berkeley.edu

UC Berkeley is one of the nation's top producers of science PhDs. It also is among the top-ranked institutions in awarding science PhDs to members of groups historically underrepresented in these fields. In 2001, UC Berkeley's admissions policy changed to no longer require GRE scores for graduate admission. Instead, the GRE requirement became a departmental option. Each year, departments that use the general GRE are encouraged to de-emphasize reliance on this test, in recognition of its limitations. Departments are advised to adopt comprehensive approaches to evaluation of applicants. This presentation explains the varied ways that departments respond to the university policy. It describes comprehensive review implementation and outcomes. In particular, the presentation focuses on the range of strategies used at Berkeley in the mathematical and physical sciences to increase diversity. It considers how new approaches intersect with traditional admissions criteria and degree outcomes.

Session AH: Getting Started in PER

Location: Tate Lab 166
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 28
Time: 8:30–10 a.m.

Presider: Kathleen Harper

AH01: 8:30-9 a.m. An Example of Theory-driven Quantitative Analysis in Physics Education Research

Invited – Lin Ding, The Ohio State University, Department of Teaching and Learning, Columbus, OH 43210; ding.65@osu.edu

As the field of physics education research matures, a diverse range of methods are now being used for empirical investigations. Quantitative analysis is one of them, representing a unique paradigm useful for studying associations, regularities, and patterns in learning and teaching. As with other methods, fruitful quantitative analysis must be anchored in theory-driven frameworks in order for it to be defensible and generalizable. In this talk, I present an example of a quantitative study to highlight the role of theoretical framework in empirical PER. Drawing on the hypothesized causal influences of reasoning skills and epistemologies on content learning, this study seeks to test the relationships among these variables. Through path analysis, students' learning gains on the Force Concept Inventory is found to be causally related to their pre-instructional reasoning skills (measured by the Classroom Test of Scientific Reasoning) and epistemologies (measured by the Colorado Learning Attitudes about Science Survey). Interestingly, post-instructional epistemology does not appear to be a significant causal factor for learning gains.

AH02: 9:30-10 a.m. Getting Started: Physics Education Research and the Upper Division

Invited – Michael Loverude, California State University, Fullerton, 800 N State College, Fullerton, CA 92834; mloverude@fullerton.edu

The field of Physics Education Research (PER) has achieved many successes. Systematic investigations have revealed innumerable insights into student thinking at the introductory level, and the results of this work have led to the development and assessment of research-based instructional materials and assessment instruments. More recently a number of researchers have focused their attention on upper-division physics courses; these courses make up a large portion of the course offerings in most departments but tend to serve a far smaller number of students. Well established results from PER performed at the introductory level have allowed researchers to start on a firm foundation, but research in the upper division has led to a different set of challenges and opportunities. In this talk we will briefly explore the landscape of upper-division PER, characterize the existing literature, and point to some promising new directions.

AH03: 9-9:30 a.m. Getting Started in PER: Gender and Ethnic Minorities

Invited – Laura McCullough, University of Wisconsin-Stout, Physics Department, Menomonie, WI 54751; mcculloughl@uwstout.edu

This talk provides an introduction to Physics Education Research (PER) related to two under-represented populations in physics: women and ethnic minorities. The talk will begin with a brief overview of historical data on the participation of women and minorities in physics. Most of the talk, though, will focus on some of the questions that PER has asked regarding how physics education practices affect women and minorities. For example, what research is there on conceptual tests and women and minorities? How might different pedagogies affect these populations? How does stereotype threat help or hinder performance of men and women in physics? While not exhaustive, this talk will give audience members a good understanding of the current status of gender and minorities research in PER.

Session AI: Introductory Labs and Apparatus

Location: Tate Lab 170
Sponsor: AAPT
Date: Monday, July 28
Time: 8:30–9:30 a.m.

Presider: Sam Sampere

AI01: 8:30-8:40 a.m. Development of Students' Scientific Abilities Through In-lab Inquiry-based Oriented Instruction

Contributed – Sergio Flores Garcia, University of Juarez, 1424 Desierto Rico, El Paso, TX 79912; seflores@uacj.mx

Juan E. Chavez-Pierce, Luis L. Alfaro-Avena, Sergio M. Terrazas-Porras, Jose V. Barron, University of Juarez

Inquiry-based physics is integrating in-lab learning approaches. The five phases of inquiry-based conceptual understanding are: 1) Design: We propose two or three questions and one hypothesis. Students ask three more questions and establish a new hypothesis. Students generate a general question, specific questions, and a hypothesis during the first phase. These questions and the hypothesis are the central axis of the cognitive strategy; 2) Preparation: Students design a new experiment. They draw a sketch of the components and prepare a list of equipment and materials to develop the physical learning situation; 3) Experimentation: Students choose equipment and material from a hardware storage to achieve scientific abilities; 4) Measure: Students use equipment to generate motion graphs; and 5) Discussion: This phase is related to the exploration of a possible meaningful understanding by answering conceptual questions based on the content of the experimentation. We will present students' mechanics understanding results to compare both treatment and control groups collected in the University of Juarez Mexico.

AI02: 8:40-8:50 a.m. Facilitating Collaboration in an Online Introductory Astronomy Laboratory

Contributed – Bruce Palmquist, Central Washington University, Ellensburg, WA 98926-7422; palmquis@cwu.edu

Student collaboration is an important component of laboratory experiences. In my online introductory astronomy class, students use Google Docs, a free online word processor that lets them collaborate synchronously or asynchronously. At the start of the term, students are assigned to heterogeneous ability groups. Each group gets a unique link to a given week's lab activity template. The instructor controls when students can add content to the template and can even work with the students on the report if they need help. No documents are emailed back and forth. After the due date, the instructor makes the template "read only" and provides feedback to the group on their lab template. To ensure effective collaboration, each student fills out a Google Form evaluating the quality and quantity of work done by group members. A student's lab report grade is a combination of the lab points earned and the peer grade.

AI03: 8:50-9 a.m. Hybrid Visual-tutorial Instruction Model to Learn the Concept of Electric Charge

Contributed – Maria D. Gonzalez, Tecnologico de Juarez, Valle de Batopilas 11429 Ciudad, Juarez, Ch 31310, Mexico; mdolores@nmsu.edu

Juan Luna-Gonzalez, Jesus Estrada-Cabral, Luis L. Alfaro-Avena, Oscar Ruiz, University of Juarez

The University of Juarez and the University of Texas at El Paso have developed a hybrid-instruction instructional model to combine lab activities and a tutorial-based inquiry through the use of a video. Students from the introductory physical sciences courses can construct the concept of electric charge. Data were collected through a post-test, a pre-test and a conventional lab designed in the same context of the corresponding learning topics. Students are exposed to a 20-min video previously to the lab activities. This video is available for students thought the whole lab. Students have the option to watch any section of the video as many times as they need it. Results show that students' questions related to lab procedures and conceptual content are reduced. Finally, we will present the corresponding learning gains and the possible mechanics-electricity transfer of knowledge of both, treatment and control groups.

AI04: 9-9:10 a.m. Measuring Centripetal Acceleration with a Liquid Accelerometer

Contributed – D. G. Sumith P. Doluweera, Georgia State University, Atlanta, GA 30303; ddoluweera@gsu.edu

Brian D. Thoms, Olesya I Olesya, Maria Rusert, Carola Butler, Joshua Von Korff, Georgia State University

As a comprehensive PhysTEC site, GSU has undertaken a reform of calculus-based introductory physics. As part of this reform, a new experiment was developed to enhance students' conceptual understanding of centripetal acceleration. The experiment was done before introducing forces and just after discussing acceleration in two dimensions. The behavior of liquid accelerometer under linear acceleration was explained and demonstrated to students without discussing dynamics. Then they were asked to use the liquid accelerometer to observe the direction of centripetal acceleration and qualitative changes in magnitude of the centripetal acceleration with radius and angular speed. The experiment was designed as a guided inquiry. Students used the equation for liquid accelerometer to measure centripetal acceleration at a point in a rotating platform and tested out the theory learned in class as a hypothesis. The experiment and student responses are discussed.

AI05: 9:10-09:20 a.m. Measuring the Acceleration Due to Gravity

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

Racing is the sport of kings, but finding the value of the acceleration due to gravity is the sport of physics teachers. I once laid out a schedule of first-semester labs in which each one resulted in a value of "g". Fortunately, cooler heads prevailed. In this talk I will discuss a number of ways to measure this value that have been used in the past.

AI06: 9:20-9:30 a.m. A Single Drop Milikan's Experiment

Contributed – Dag Hanstorp, University of Gothenburg, Kemivägen 9 Gothenburg, SE 412 96 Sweden; dag.hanstorp@gu.se

Oscar Isaksson, Magnus Karlsteen, Chalmers University of Technology

Mats Rostedt, University of Gothenburg

I will present an experimental set-up in which optical levitation is combined with Millikan's classical oil drop experiment. An oil drop trapped in a focused vertically aligned laser beam is made to oscillate by applying an alternating electric field. The position of the drop is observed by imaging scattered laser light onto a screen and the radius of the drop is measured by detecting the diffraction pattern produced when illuminated with a horizontally aligned He-Ne laser beam. The number of excess charges on the drop can be measured, and number of charges can be reduced by exposing it to a radioactive source. The goal of the project is to design a system that can be used to demonstrate several fundamental physical phenomena using the bare eye as the only detector. The experiment can be used for classroom demonstrations or as a laboratory exercise on the college level.

Ceremonial Session: Welcome; 2014 AAPT Teaching Awards; 2014 Homer L. Dodge Citations for Distinguished Service

Location: Northrop Auditorium
Date: Monday, July 28
Time: 10:30 a.m.–12 p.m.

Presider: Mary Mogge *Presenter: Gay Stewart*

Ruth Chabay

Bruce Sherwood

David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching, 2014 – Ruth Chabay and Bruce Sherwood

Ruth Chabay and Bruce Sherwood, Department of Physics, North Carolina State University, emeritus, Raleigh, NC 27607; rwchabay@ncsu.edu; bruce_sherwood@ncsu.edu

Inviting Students Into the 21st Century

In the early 1900s it was not unreasonable to assume that most students who took physics in college were going to go out and maintain pumps and build bridges. In 2014 that's no longer a reasonable assumption. The interesting problems of the 21st century are difficult and complex, and typically involve the intersection of several disciplines. Our students will work on climate change and sustainability, on medicine and cellular biology and ecology, on information security, on the design of wearable computer hardware, on energy production and storage, and on problems we haven't yet thought of. The introductory physics course can support these students by inviting them into the 21st century, building on the insights and paradigm shifts of 20th century physics. The structure of matter and macro-micro connections, the primacy of a small number of fundamental principles, the process of constructing, testing, and extending physical models, and computational modeling that allows students to see how complex behavior can emerge from simple physical rules, should all be central in 21st century introductory physics.

Bradford Hill

Paul W. Zitzewitz Award for Excellence in Pre-College Physics Teaching, 2014 – Bradford K. Hill

Bradford K. Hill, Southridge High School, Beaverton, OR 97008; bradford_hill@beaverton.k12.or.us

Citizen Science: Harnessing Physics to Advance Science and Mathematical Literacy

Cultivating an understanding of physics is an important profession. Being part of young peoples' lives as they come to discover the beauty of physics is compelling. Nurturing the habits of mind of a scientist is consistently energizing and meaningful. Our youth need experiences with critical thinking across the curriculum, but for me it is a joy to achieve part of this through physics. Especially, as in my mind, high school level physics is in a unique position to bring students from a place of wild guessing to evidence-based argumentation in 90 minutes or less numerous times a semester. Physics, especially with an engineering and mathematical focus, has both "quantity and quality" opportunities to have students make data-driven decisions and to experience science. I first invite my students in with the question: "How do we find and use patterns in nature to predict the future and understand the past?" and then the search for patterns begins.

Homer L. Dodge Citations for Distinguished Service to AAPT

Dyan Jones
Assistant Professor of Physics, Mercyhurst University, Erie, PA

Paul J. (Joe) Heafner
Physics and Astronomy Instructor, Catawba Valley Community College, Hickory, NC

Martha Lietz
Science Teacher
Niles West High School, Skokie, IL

Evelyn Restivo
144 Creekview Circle, Maypearl, TX

TOP02: Topical Discussion: Trouble-shooting Apparatus

Location: STSS 420B
Sponsor: Committee on Apparatus
Date: Monday, July 28
Time: 12–1:30 p.m.

Presider: Luke Donforth

If you have lab equipment that doesn't work or makes you believe in poltergeists, if you have a new use for old equipment that you want to share, or if you have stuff in storage you can't even identify, bring pictures and we'll have a roundtable discussion on keeping the objects of hands-on education functional.

TOP03: Topical Discussion: Physics and Society

Location: Tate Lab 210
Sponsor: Committee on Science Education for the Public
Date: Monday, July, 28'
Time: 12–1:30 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.

TOP04: Topical Discussion: PER Solo Faculty

Location: STSS 432A
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Professional Concerns
Date: Monday, July, 28
Time: 12–1:30 p.m.

Presider: Steve Maier

Are you the only professional active in PER within your department? Are there only one or two colleagues in close proximity you can talk "PER shop" with? The membership of Solo PER is larger than you may think, and more diverse than most suspect. Join us for this crackerbarrel to connect with other Solo PER professionals and learn what is being done to help our/your endeavors. As in the past, bring questions, ideas, and professional concerns to share.

TOP01: Topical Discussion: YouTube Share-a-thon

Location: Tate Lab 210
Sponsor: Committee on Physics in High Schools
Date: Monday, July, 28
Time: 1:30–3 p.m.

Presider: Dean Baird

Show us a favorite YouTube video for use in physics instruction. And tell us how you use it. We'll have a computer connected to the Internet, a projector and speakers. You bring the video's web address and, say, 50 copies of curriculum materials you use with the video (or a URL for the PDF). This session is always great fun in addition to being a treasure-trove of instructional gems; laughter is guaranteed!

Session BA: Panel – MOOCs and You

Location: STSS 312
Sponsor: Committee on Educational Technologies
Date: Monday, July 28
Time: 1:30–3:30 p.m.

Presider: Saif Rayyan

We'll cut through the hype about MOOCs (Massive Open Online Courses) to present what physics teachers and education researchers might want to know about them: What MOOCs are available in physics? How are they different? What are the implications of MOOCs on introductory physics offerings? How can you blend one with your on-campus course? Do people learn anything in them, what insights offered for teaching on-campus courses, and what opportunities do they offer to the education research community? This panel will provide an overview of MOOCs, short contributions by people who've run Physics MOOCs, followed by questions and discussion.

BA01: 1:30-3:30 p.m. From Online to Blended: Making the Transition

Panel – John W. Belcher, MIT, Massachusetts Ave., Cambridge, MA 02139; jbelcher@mit.edu

Saif Rayan, Peter Dourmashkin, Lori Breslow, MIT

The MIT Physics Department has offered two edX MOOCs based on our introductory physics courses in mechanics and electromagnetism. The department built these online offerings around the 35 recordings of Professor Walter Lewin's lectures in each subject, complete and in sequence. Each course had about 30,000 initial registrants, with about 2000 certificates granted. The structure of the online courses paralleled that of the residential course. Based on our experience in building these courses online, we are now using the same platform in residential education at MIT to provide resources to students, in a blended approach. The key to realizing the potential of technology in education is the collaboration of experts in teaching and learning, educational researchers, computer scientists, and disciplinary specialists, and we have assembled such a team to guide us in our residential use of the edX platform, as we will discuss.

BA02: 1:30-3:30 p.m. Affordances of MOOCs and Humans: A Study Comparing in-person and MOOC Offering Instruction in Physics 1

Panel – Noah D. Finkelstein, University of Colorado, Boulder, UCB 390- Dept. of Physics, Boulder, CO 80309; finkelsn@colorado.edu

Michael Dubson, Katherine Goodman, Edmond Johnsen, Jack Olsen, University of Colorado Boulder

David Lieberman, Queensborough College

With all the attention to MOOCs, in fall 2013 we set out to explore this space, create and offer a MOOC, and to conduct a research study on how it was offered, how it was used, and the impacts on student learning and participation. Physics 1 for Physical Science Majors was simultaneously offered through Coursera and to a live class. Through a variety of measures (of student learning, participation, demographics), we found a variety of take-home messages from these various media. We find that this MOOC: supported participants in different ways (pedagogically, temporally, and geographically), demonstrated that students can learn in these environments, addressed different audiences, tended to select for high- performing (well-prepared) students, limited potential forms interactivity, and caused significant consternation at the university administrative level. Many more details will be found in Dubson's talk Wednesday afternoon. In this session, we seek to engage in a(n evidence-based) discussion, based on community interest [the YOU part] on: how to run, lessons learned, opportunities / concerns, politics, research studies needed and more.

BA03: 1:30-3:30 p.m. A Physics MOOC That Helps Students, Researchers, and Teachers Learn*

Panel – David E. Pritchard, MIT Room 26-241 / 77 Mass. Ave., Cambridge, MA 02139-4307; dpritch@mit.edu

Kimberly R. Colvin, John Champaign, Alwina Liu, Colin Fredericks, MIT

The RELATE group (http://RELATE.MIT.edu) is now running its fourth MOOC, 8.MReV on edX.org. Pre-post testing showed normalized gain of 0.31+/-0.02 independent of student initial skill or cohort with over 1000 receiving certificates. This and other learning correlates differently with time spent using various available resources. Our special track for teachers has forums on how to teach various topics, and for suggesting and vetting external resources. Our MOOC is a "user facility" for PER researchers who wish to run experiments using a control/experimental group protocol, or to vet assessment instruments. Currently nine researchers are collaborating on seven projects: three are developing or testing instruments to measure various aspects of problem solving ability, three are developing new ways to understand and teach problem-solving expertise, and two involve using multi-dimensional psychometrics to discover whether actual student skills depend more on learning objective, cognitive category, question type, or question format. More collaborators are sought.

*Work supported by NSF, MIT, and Google.

Session BB: PER: Exploring Problem Solving Approaches and Skills

Location: STSS 220
Sponsor: AAPT
Date: Monday, July 28
Time: 1:30–3:10 p.m.

Presider: Andrew Boudreaux

BB01: 1:30-1:40 p.m. Assessing Online Computer Coaches for Problem Solving: Measures of Utility

Contributed – Koblar A. Jackson, Central Michigan University, Department of Physics, Mt. Pleasant, MI 48858; jacks1ka@cmich.edu

Evan Frodermann, Ken Heller, Leon Hsu, University of Minnesota-Twin Cities

Andrew Mason, University of Central Arkansas

The Physics Education Research Group at the University of Minnesota (UMN) is investigating the utility of a type of online computer coach to promote learning and aid in the development of problem-solving skills in an introductory physics course. The first version of these coaches was used in the first semester of large calculus-based introductory mechanics courses at UMN. The utility of the coaches depends on their ease of use and their attractiveness to students as well as their efficacy. In this talk, we describe the techniques used to measure the utility of the coaches when used as a part of the introductory course. This talk will also address the natural use of the coaches by different segments of the student population within the class. Q. Ryan, B. Aryal, and J-L. Lin also contributed to this work. This project was partially supported by NSF DUE-0715615 and DUE-1226197.

BB02: 1:40-1:50 p.m. Assessing Online Computer Coaches for Problem Solving: Educational Impact

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

Jennifer Docktor, University of Wisconsin-La Crosse

Ken Heller, Leon Hsu, Qing Ryan, University of Colorado Boulder

The Physics Education Research Group at the University of Minnesota is developing a set of online computer coaches to aid student learning in an introductory physics course. This talk reports on the educational impact of implementing the first version of these coaches in the first semester of several large calculus-based introductory mechanics courses. The talk will also address how the results of this implementation are being used as input to the design of the second version of these coaches. A. Mason, B. Aryal, J-L. Lin, and K. A. Jackson also contributed to this talk. This work was partially supported by NSF DUE-0715615 and DUE-1226197.

BB03: 1:50-2 p.m. Influence of Visual Cueing and Correctness Feedback on Problem Solving*

Contributed – Elise Agra, Kansas State University, Department of Physics, Manhattan, KS 66506; esgagra@gmail.com

Xian Wu, Mitchell Burkett, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Research has demonstrated that using visual cues can help to direct students' attention to relevant areas of a diagram and facilitate problem solving. In this study, we investigate the effect of visual cues and correctness feedback in conceptual physics problems containing a diagram with respect to the comprehension of physics concepts. Students enrolled in an introductory mechanics course were individually interviewed. Using think-aloud protocol, students worked through four sets of problems containing a diagram. Each problem set contained an initial problem, six isomorphic training problems, a near transfer problem, and a far transfer problem. The students provided verbal responses to the problems. 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. We discuss the influence of both cueing and feedback on students' ability to solve the training and transfer problems.

*This material is based upon work supported by the National Science Foundation under Grant Nos. 1138697 and 1348857.

BB04: 2-2:10 p.m. Visual Cues Increase Efficiency in Extracting Relevant Information from Diagrams*

Contributed – Amy Rouinfar, Kansas State University, Department of Physics, Manhattan, KS 66506; amy.rouinfar@gmail.com

Elise Agra, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Adam M. Larson, University of Findlay

Visual cues overlaid on diagrams and animations can help students attend to relevant features and facilitate problem solving. In this study we investigated the effects of visual cues on students' eye movements as they solved conceptual physics problems. Students (N=80) enrolled in an introductory physics course individually worked through four sets of problems, each containing a diagram, while their eye movements were recorded and provided verbal responses. The problem sets contained an initial problem, six isomorphic training problems, and a transfer problem. Those in the cued condition saw visual cues overlaid on the training problems. Each diagram contained regions that were alternatively relevant to solving the problem correctly or related to common incorrect responses. The cued group more accurately answered the transfer problems (which did not have cues), and their eye movements showed they more efficiently extracted the necessary information from the relevant area than the uncued group.

*This material is based upon work supported by the National Science Foundation under Grant No. 1138697.

BB05: 2:10-2:20 p.m. The Effects of Problem-solving Training on Students' Reasoning Abilities*

Contributed – Xian Wu, Kansas State University, Manhattan, KS 66506; xian@phys.ksu.edu

Elise Agra, Claudia Fracchiolla, N Sanjay Rebello, Kansas State University

We study the effects of a computer-based training process on pre-service elementary teachers' reasoning on introductory physics problems with diagrams. The training process contains four problem sets that target commonly known naïve conceptions in physics. The problems include physics diagrams and text and require conceptual reasoning rather than computation. Each problem set has three training problems followed by solutions, one near transfer problem, and one far transfer problem. We have analyzed students' verbal answers to elucidate the reasoning resources that they activated to construct the different explanations that they gave in response to the problems. We found that the students changed their reasoning dramatically through the process as they were presented with solutions to training problems and later posed a transfer problem. Our results provide insights into students' activation of their resources and the procedures they used to construct their reasoning in response to the training problems.

*This material is based upon work supported by the National Science Foundation under Grant No. 1138697 and 1348857.

BB06: 2:20-2:30 p.m. Developing Expertise Beyond Conceptual Understanding Through Deliberate Practice

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

Pritchard David, MIT

Achieving physics expertise requires various expert skills beyond conceptual understanding, such as mapping between different representations, or devising a qualitative overall plan. Research have shown that the most effective method to develop expertise in any field is through "deliberate practice": carefully designed repetitive practice focused on a specific expert skill. However, most traditional back of the textbook problems are poor candidates of deliberate practice activities, as they often require multiple skills to solve. We will briefly introduce our initial attempts of developing "deliberate practice problems" for introductory mechanics. These highly focused problems are carefully designed to train one aspect of expert skill at a time, utilizing the new "Drag and drop" format of the edX platform to reduce extraneous cognitive load. We will show a couple of example problems, and also report the initial response from students when we deploy those problems in a flipped classroom.

BB07: 2:30-2:40 p.m. Analyzing Resources Used by Expert Physicists While Reasoning Towards Understanding

Contributed – Darrick C. Jones, Rutgers, The State University of New Jersey, Piscataway, NJ 08854-8019; dcjones@physics.rutgers.edu

AJ Richards, Eugenia Etkina Rutgers, The State University of New Jersey

Gorazd Planinsic, University of Ljubljana

One important goal for physics education is to help students develop reasoning patterns similar to those of physicists. But what does a physicist actually do that enables her/him to successfully understand and solve challenging, novel problems? To answer this question we performed fine-grained discourse analysis on video recordings of physics experts attempting to solve novel problems using the framework of resources. We focused on episodes during the problem solving process when experts reasoned towards a deeper understanding of the phenomenon they were observing. By searching for patterns across many episodes, we identified candidate resources with epistemological underpinnings, which help experts when they are making conceptual breakthroughs when solving novel problems. We discuss the frequency with which resource candidates were used by experts and the instructional implications of these findings.

BB08: 2:40-2:50 p.m. Skipping the First Step: Physical Process Understanding in Problem Solving

Contributed – Katherine Ansell, University of Illinois at Urbana-Champaign, Urbana, IL 61801; crimmin1@illinois.edu

Mats Selen, Timothy Stelzer, University of Illinois at Urbana-Champaign

Multiple-choice tests are commonly used in large introductoryphysics courses, but the format provides limited information about specific student weaknesses in problem solving. We seek to identify and characterize the role of physical process understanding in a multiple-choice format. To do this, we have written a collection of questions designed to assess students' understanding of the physical processes that occur in given scenarios. These questions were given to students in an introductory calculus-based mechanics course in a review context for each of the major examinations in the course. We have compared student performance on these questions to student performance in examinations and will discuss what these results reveal about this specific type of understanding in problem solving.

BB09: 2:50-3 p.m. Mathematics Skills in Physics Problem Solving

Contributed – Jing Wang, Eastern Kentucky University, Richmond, KY 40475; jingwangky@gmail.com

Jerry Cook, Eastern Kentucky University

Andrew Boggs, Madison Central High School, Richmond, KY

Students' mathematical skill level is often considered a good indicator of their success in introductory physics courses. It is a common expectation that students who meet the prerequisite requirement will be well-prepared; however, this is rarely the case. In a recent study at the Department of Physics and Astronomy of Eastern Kentucky University, a math diagnostic test is given pre-instruction in an algebra-based physics course to evaluate their math skills. We then interviewed six students who were on the borderline in the entrance math diagnostic test. To investigate their physics problem solving skills, we gave them questions that included both math-intensive questions and context rich problems. The connection between students' mathematical skills and their physics problem-solving skills is discussed in detail.

BB10: 3-3:10 p.m. Grading Problem-solving Items Using Rubrics in Large Groups

Contributed – David Menard, Polytechnique Montreal, 2500 Chemin de Polytechnique, Montreal, QC H3T 1J4 Canada; david.menard@polymtl.ca

Maxim Morin, University of Montreal

Thomas Gervais, Polytechnique Montreal

Assessment of problem-solving skills often poses some challenges in science programs. In particular, in large groups, for which several raters are involved, the question of the validity and reliability of the grading process can be legitimately challenged. A common approach to grading is to exploit a scoring scheme into which partial credits are attributed to distinct steps of the solution and points are deduced for errors. In the present work, two studies have been conducted to investigate whether the alternative use of rubrics may improve the grading process. The first was concerned with determining whether or not the rubrics developed for a class of freshman mechanics improve the scoring when compared to the traditional method. The second study used a revised version of the rubrics to verify the hypothesis that, with proper training, grading problem-solving using rubrics increases grading speed, agreement between graders and overall transparency of the grading process.

Session BC: Creating Research-like Experiences for All Students II

Location: Tate Lab 170
Sponsor: Committee on Apparatus
Date: Monday, July 28
Time: 1:30–2:50 p.m.

Presider: Ben Zwicki

BC01: 1:30-1:40 p.m. The S-Lab: Research Experiences for All Students

Contributed – Stephen Mecca, Providence College, Dept. of Engineering-Physics-Systems, Providence, RI 02908; smecca@providence.edu

The S-Lab (as it has been recently named) has been operating in its current state for over a decade in the Department of Engineering-Physics-Systems at Providence College creating and managing meaningful research experiences for many students both in the sciences and in other academic departments. This paper outlines the approach used in the lab, the student commitment, the physical and software tools (that include a recent implementation of lab archives), as well as some of the recent projects that have been undertaken. The lab experience for students has been significant. The impacts of S-Labs projects around the world especially in water, sanitation and education will be highlighted.

BC02: 1:40-1:50 p.m. The Development and Implementation of a Senior Research Course

Contributed – Timothy A. Duman, University of Indianapolis, Indianapolis, IN 46227-3697; tduman@uindy.edu

This presentation will follow the development and implementation of our senior research (Phys 490) course at the University of Indianapolis. Phys 490 was designed so that a student would get experience with the following methods: theoretical, experimental and computational techniques used by physicists to solve problems. The idea behind this course is that a student would work on the same project but use these techniques to approach the problem. The student chooses their own project with the advice of an instructor. Students in this course were also required to present their work in three different ways: a written paper, a poster and an oral presentation.

BC03: 1:50-2 p.m. Authentic Research in the Undergraduate Curriculum at Austin College

Contributed – Andra Troncalli, Austin College, Sherman, TX 75090; atroncalli@austincollege.edu

David Baker, Don Salisbury, Peter Hyland, Austin College

At Austin College, we believe that students learn physics best by doing physics. What better opportunity for our students to do physics and be active participants in their learning than by conducting authentic scientific research? Our physics majors (minors) are required to take two (one) of our "Research Experience in Physics" courses. Students work in small groups on independent research projects under the supervision of a faculty member. Research areas match the faculty members' expertise and interests, which include Superconductivity, Cosmology, Weather, and Observational Astronomy. We will present recent research investigations and discuss the benefits of these courses both to our current students and to our graduates.

BC04: 2-2:10 p.m. Implementing Instructional Research Labs to Give Students Authentic Scientific Experiences in a Classroom Environment

Contributed – Benjamin L. Stottrup, Augsburg College, Department of Physics, Minneapolis, MN 55454; stottrup@augsburg.edu

Sarah B. McKagan, American Association of Physics Teachers

We describe an approach to giving students authentic scientific experiences in a classroom environment, which we refer to as an instructional research lab. Instructional research labs are designed to replicate many of the benefits of undergraduate research, along with addressing many of its shortcomings, in a classroom environment. The goals of this approach are for students to engage in and understand authentic scientific practices and to develop identities as scientists. Students achieve these goals through developing research questions, planning experiments to carry them out, troubleshooting the inevitable problems that arise in these experiments, building on the work of others, collaborating in groups, writing proposals, keeping lab notebooks, and presenting their work. Our instructional research labs are implemented in the laboratory portion of a sophomore-level modern physics class at Augsburg College, and focus on the research topic of creating and characterizing hydrophobic surfaces, a topic that takes advantage of local resources and expertise. We describe our implementation of instructional research labs, as well as the underlying principles of our approach, which we believe could be applied in many other instructional environments using different research topics, resources, and expertise.

BC05: 2:10-2:20 p.m. Assessing the Impact of Instructional Research Labs on Students' Scientific Practices and Science Identities

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

Benjamin L. Stottrup, Augsburg College

We report on a study of the impact of sophomore-level modern physics labs designed to give students authentic research experiences and support them in developing identities as scientists. In these labs, students propose their own research questions, develop plans to answer them, and carry out those plans, modifying them as necessary to address unexpected issues that inevitably arise. We demonstrate the effectiveness of these labs using evidence from analysis of questions during students' final presentations and from student interviews. We show that these labs support students in (1) engaging in authentic scientific practices, (2) giving accurate descriptions of the practices of scientists that are rooted in their own experiences, and (3) shifting from identifying as scientists in the future to identifying as scientists in the present. We argue that the third shift is caused by a metacognitive awareness of the first two shifts. That is, not only are students engaging in scientific practices and understanding what scientists do, but they are aware that they are doing so, and are excited and empowered by this awareness.

BC06: 2:20-2:30 p.m. From Prepared Instructions to Self Reorganized Experiments

Contributed – Fuli Zhao, Sun Yat-sen University, School of Physics and Engineering, 510275 China; stszfl@mail.sysu.edu.cn

Han Shen, Min Chen. Xintu Cui, Sun Yat-sen University

From the traditional instructions we have established a new set of experimental instructions called three periods training program in the course of General Physics Experiment at Sun Yat-sen University. The first period is focused on the regular measurements of basic physical quantity. The purpose is to make students be familiar and skillful with scientific measurement including the scientific notation and the analysis of experimental uncertainty. The second period is focused on the recognition of physics laws and relationships. In this period, the students can think in physics and with clear intention to find the relationships between certain parameters as well as the propagation of error. The third period is focused on the experiment with open questions and contents. The goal is to spark the students to start making research-like works including reorganizing research materials and writing experimental reports with the journal style and most importantly find their own views in the open part of the experiment. This work is supported by NSFC J1103211 and J1210034

BC07: 2:30-2:40 p.m. Frictionless Racquetball?

Contributed – Mikhail Kagan, Penn State Abington, 1600 Woodland Rd. Abington, PA 19001-3918; mak411@psu.edu

When a ball hits a surface, does the angle of reflection always equal the angle of incidence? Not at all! Depending on the interplay of the ball's spin and speed and the force of friction, the ball's behavior after the bounce may differ dramatically. Surely some experienced racquetball, Ping-Pong, pool, tennis, and players alike take advantage of this fact. A physics teacher, in turn, can take advantage of the fact that by observing the bounce of a ball her students can determine the coefficient of friction between the ball and the floor. All it takes is a typical video (smartphone) camera and some standard software. To challenge the students beyond this standard exercise and to create a research-like opportunity for them, the teacher can then arrange for a "frictionless bounce."

BC08: 2:40-2:50 p.m. A Versatile Lab for Research by Students at All Levels

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

The Innovation Hyperlab serves students from middle school to graduate level. It is a university-grade research environment located in a former auto-shop building next to Gateway High School in Aurora, CO. The lab houses resources for 52 different technologies, such as mechanical components, analogy electronics, optical systems, micro-controllers, and nanoparticles. A website under development supports learning "on demand" about each technology. Components of the web-based learning can be assembled like LEGO(TM)-bricks into regular curricula at different levels (8th grade to graduate). A Saturday program engages K-12 students, undergraduates, teachers, and university faculty in collaborative research and innovation. Going well beyond the notion of a "maker space," the Innovation Hyperlab provides access to a broad range of the tools of applied physics and engineering in a single location and can disseminate resources to schools around the Colorado region.

Session BD: Teaching Advanced/ Honors Students

Location: Tate Lab 131
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 28
Time: 1:30–2:40 p.m.

Presider: Juan Burciaga

BD01: 1:30-2 p.m. Keeping it Fresh: An introductory Physics Sequence for any Background

Invited – Dwight L. Whitaker, Pomona College, Claremont, CA 91711-6301; dwight.whitaker@pomona.edu

One of the biggest challenges with serving a diverse population of students with a range of high school preparations is to structure an introductory course sequence that doesn't repeat subjects for the well prepared or alienate the less prepared. At Pomona College we have restructured our first-year physics majors' sequence so that all students start with the same course. To keep the material fresh and challenging for all the students, they start with a course that covers material usually reserved for a third semester "modern physics" course (special relativity, quantum mechanics, and statistical physics). By pitching these subjects at a level that all students can grasp, we create a cohort of majors that all start in the same place, which we believe improves our retention of majors. After their first semester, students then take a semester of mechanics and E&M, which the most advanced students can place out of and move onto our upper-level offerings. We are now in our fifth year of this experiment and have seen an increase in majors compared the previous model. The student feedback has also been positive.

BD02: 2-2:30 p.m. Lower Division Honors Physics at UC Davis

Invited – Joseph Kiskis, University of California at Davis, Department of Physics, Davis, CA 95616-5270; jekiskis@ucdavis.edu

The Department of Physics at the University of California at Davis offers a five quarter lower division honors physics course. This is in addition to the two non-honors sequences of large courses—one for students majoring the biological sciences and one for those in engineering and the physical sciences. The honors course is primarily for physics majors and others in the latter group, but all majors are welcome. I will describe the origin of the course about a dozen years ago, its structure, texts, and teaching methods. One of the main course goals is to introduce students to special relativity and quantum mechanics during their first year.

BD03: 2:30-2:40 p.m. Honors Labs within Traditional Lectures

Contributed – Matt Evans, University of Wisconsin - Eau Claire, 105 Garfield Ave., Eau Claire, WI 54701; evansmm@uwec.edu

Erik Hendrickson U of WI - Eau Claire

Supplying a University Honors experience in physics is difficult due to the limited numbers of students seeking this option and constraints on faculty time. Our solution is to have all students participate in the same lecture, but supply the honors students with a separate laboratory. This enables us to craft more open-ended labs, dive deeper into the material, and challenge these exceptional students without disenfranchising our regular students. Examples of labs, assigned papers, and various grading methods will be shared.

Session BE: PER in Upper Division Physics II

Location: STSS 230
Sponsor: AAPT
Date: Monday, July 28
Time: 1:30–3 p.m.

Presider: Hunter Close

BE01: 1:30-1:40 p.m. Upper-Division Student Difficulties with the Dirac Delta Function

Contributed – Bethany R. Wilcox, University of Colorado, Boulder, CO 80302; Bethany.Wilcox@colorado.edu

Steven J. Pollock, University of Colorado Boulder

The Dirac delta function is a standard mathematical tool used in multiple topical areas throughout the undergraduate physics curriculum. While delta functions are often introduced to simplify a problem mathematically, students often struggle to manipulate and interpret them. To better understand student difficulties with the delta function at the upper-division level, we examined responses to traditional exam questions and conducted multiple think-aloud interviews. Our analysis is guided by an analytic framework that looks at how students activate, construct, execute, and reflect on the Dirac delta function in physics. Here, we focus on student difficulties using the delta function to express charge distributions in the context of junior-level electrostatics. Challenges include invoking the delta function spontaneously, constructing two- and three-dimensional delta functions, integrating delta functions in different coordinate systems, and recognizing that the delta function has units. We also discuss possible implications of these findings for instruction.

BE02: 1:40-1:50 p.m. Investigations of Spin First Instructional Approach in Teaching Quantum Mechanics

Contributed – Homeyra R. Sadaghiani, Cal Poly Pomona, Pomona, CA 91768-2557; hrsadaghiani@csupomona.edu

We are investigating student learning of quantum mechanics in two different contexts. In one approach, postulates of quantum mechanics are introduced in the context of the wavefunction of a particle in a box with continuous bases of position probability densities. The second approach uses the context of Stern-Gerlach experiments with discrete spin bases. We have measured student learning of the core concepts in courses using these approaches with common exam questions and a standardized conceptual instrument. Preliminary data suggest a small but positive impact on students' scores on topics related to quantum mechanical measurement in the classes taught using the discrete bases in the second approach. Preliminary data also suggest that using the discrete bases approach may shift student focus from computation to more sense making by providing concrete experimental evidence and simplifying the mathematical calculation processes. We will discuss the implications of this study for choices of initial context, the order, and emphasis of content being taught.

BE03: 1:50-2 p.m. Student Reasoning about Superposition in Quantum Mechanics

Contributed – Gina Passante, University of Washington, Department of Physics, Seattle, WA 98195-0001; passante@uw.edu

Paul J. Emigh, Peter S. Shaffer, University of Washington

Superposition is at the heart of quantum mechanics, and yet we have found that many students struggle with this idea even at the end of instruction. Although most students can successfully use the idea of superposition to calculate probabilities of different measurement outcomes, we have found that they often fail to recognize how a superposition state differs from a mixture or from a system whose initial state is unknown. This distinction is one of fundamental importance in quantum mechanics and has implications for more complex topics such as entanglement. We present data from undergraduate and graduate-level quantum mechanics courses that illustrate some of the difficulties that students have with superposition. We also discuss how the results have guided the design of a lecture-tutorial that improves student understanding both immediately and months after instruction.

BE04: 2-2:10 p.m. Assumptions and Idealizations in Students' Reasoning During Laboratory Activities

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

Dehui Hu Rochester, Institute of Technology

Noah Finkelstein, H. J. Lewandowski, University of Colorado Boulder

Assumptions and idealizations play a significant role in developing and applying models to real-world situations. Assumptions make models more tractable, but also impact the design of experiments (through the introduction of possible sources of systematic error) and limit the range of validity of predictions. In this investigation, students conducted a think-aloud laboratory activity using LEDs. Videos were coded and analyzed using a framework developed for model-based reasoning designed for upper-division physics laboratory classes. The analysis focuses on multiple roles of assumptions within the activity: making, recognizing, and justifying assumptions; linking assumptions to limitations of the validity of theoretical predictions and measured results; and using knowledge of assumptions to iteratively improve experimental results.

BE05: 2:10-2:20 p.m. Student Learning of Critical Circuits Concepts in Physics and Engineering*

Contributed – Kevin Van De Bogart, University of Maine, Orono, ME 04469; kevin.vandebogart@maine.edu

MacKenzie Stetzer, University of Maine

As part of a new effort 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 circuits and electronics. Due to the considerable overlap in the content coverage, we have been able to administer the same (or similar) questions to students in both disciplines. A major goal of this work is to investigate the impact of disciplinary context on the nature of student understanding, including the prevalence of specific difficulties. This talk will focus on foundational concepts (e.g., loading) that are critical to the design and analysis of circuits in all courses studied. 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-1323426 and DUE-0962805.

BE06: 2:20-2:30 p.m. Conceptual Difficulties Interpreting P-V Diagrams Across Physics and Engineering

Contributed – Jessica W. Clark, University of Maine, Orono, ME 04469; jessica.w.clark@maine.edu

John R. Thompson, Donald B. Mountcastle, University of Maine

As part of a new effort to investigate the learning and teaching of concepts in thermodynamics and electronics in both physics and engineering, we have been examining student learning of thermodynamics in mechanical and chemical engineering and physics courses. Based on free-response surveys and individual interviews, we find that students in all disciplines have difficulty with the first law of thermodynamics and its constituent elements: students either do not recognize its relevance or use it improperly. At the beginning of each of these courses, a majority of students treat work as a path-independent function (i.e., as if it were a state variable). This and other lines of reasoning, particularly relating to graphical interpretations of work, persist through instruction, although the degree of persistence varies by discipline. We will share findings about the relative prevalence of lines of reasoning and will relate our results to individual disciplinary emphases and pedagogies. The work described has been supported in part by the National Science Foundation under Grant Nos. DUE-0817282 and DUE-1323426.

BE07: 2:30-2:40 p.m. Understanding the Neural Correlates of Problem Solving Across Multiple Cognitive Domains

Contributed – Jessica E. Bartley, Florida International University, Miami, FL 33199; jbart047@fiu.edu

Kimberly L. Ray, Michael C. Riedel, Research Imaging Institute, University of Texas Health Science Center San Antonio

Eric Brewe, Angela R. Laird, Florida International University

Complex reasoning and problem-solving are integral cognitive constructs relevant to understanding how students acquire critical thinking skills in physics. Functional magnetic resonance imaging may offer neurobiological insight into how these critical thinking skills are acquired. Prior work studying the neural correlates of problem-solving has focused within specific cognitive domains, e.g. mathematical calculation, verbal problem-solving, or visuospatial reasoning.[1,2] However, research identifying neural networks engaged during physics problem-solving is limited. We use the BrainMap database[3] to perform a series of neuroimaging meta-analyses across multiple distinct cognitive domains likely involved in physics problem-solving. Common activation patterns are observed in the bilateral insula, mid and superior frontal gyrus, and parietal cortices, suggesting that reasoning across domains is supported by a superordinate problem-solving network.

1. S.D Newman et al, *Brain Research* 1410, 77-88 (2011).
2. V. Prabhakaran et al, *Cog Psych* **33**, 43-63 (1997).
3. A.R. Laird et al, *Neuroinformatics* **3**, 65-78 (2005).

BE08: 2:40–2:50 p.m. Uses of ICT in Teaching Physics

Contributed – Oscar Jardey OJS Suarez, Universidad Distrital Francisco José de Caldas, Carrera 3a Calle 26, Bogotá, AA 11001 Colombia; sistemas29@hotmail.com*

This paper seeks to identify the use of ICT Information Communication Technologies by teachers in teaching practices. The source of information corresponds to reports in the last five years that appeared in magazines such as *Colombian Journal of Physics*, *Latino American Journal Physics Education*, *Revista Brasileira de Ensino Physics, Journal of Research and Teaching Experiences*, *Journal of Physics*, *The Physics Teacher Online*, the *Journal of Engineering Education,* among others. This is a methodically informational analysis accompanied by theoretical reflection on the context of an epistemological approach to teaching physics to engineering. Among the main findings is that ICTs have been incorporated as a mediating element between the physical knowledge and physical learning and as mediating artifacts of the dynamics present in physics laboratories.

* PhD in Education with an emphasis in Science Physics Teacher Fundación Universidad Autónoma de Colombia. Research Project "Learning objects as cultural artifacts: conceptions of physics teachers working in the faculty of engineering". Partially financed by the Research Center University District Francisco José de Caldas

BE09: 2:50-3 p.m. Addressing Student Difficulties with non-Cartesian Unit Vectors in Upper-Level E&M

Contributed – Brant E. Hinrichs, Drury University, Springfield, MO 65802; bhinrichs@drury.edu

An upper-level E&M course (i.e. based on Griffiths) involves the extensive integration of vector calculus concepts and notation with abstract physics concepts like field and potential. We hope that students take what they have learned in their math classes and apply it to help represent and make sense of the physics. In a 2010 PERC paper I showed how students at different levels (pre-E&M course, post-E&M course, 1st year graduate students) and in different disciplines (physics, electrical engineering) have difficulty using non-Cartesian unit vectors appropriately. I have now developed a small sequence of in-class activities to help students over come these kinds of difficulties. I present preliminary evidence here on their effectiveness.

Session BF: Outreach: Fun Ways to Engage

Location: Tate Lab 133
Sponsor: Committee on Science Education for the Public
Co-Sponsor: Committee on Physics in Pre-High School Education
Date: Monday, July 28
Time: 1:30–3:20 p.m.

Presider: Jeremy Benson

BF01: 1:30-1:40 p.m. Catch a Wave and SWIM to LIGO!

Contributed – Kathy Holt, LIGO -LLO Science Education Center, 19100 LIGO Lane, Livingston, LA 70754; kholt@ligo-la.caltech.edu

SWIM-Science With Inexpensive Materials! The LIGO Science Education Center uses inexpensive materials for activities and demonstrations to explain physical science concepts. Experience eight SWIM activities in eight minutes. These SWIM activities have been field tested with the public and are just downright fun! Come be inspired and motivated with ideas that will engage and delight the public and can be useful at any grade level.

BF02: 1:40-1:50 p.m. Western Kentucky Physics Olympics: A Regional Success Story

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

Jason Boyles,Keith Andrew, Western Kentucky University

Building upon the legacy of previous Physics Olympics at other institutions (Riban, 1976, *Phys. Teach.* **14**, 471), the Western Kentucky Physics Olympics is a one-day team pentathalon competition. Our university was part of the early Physics Olympics movement; however, by the mid-90s it had managed to lose its way. When the 25th anniversary of Physics Olympics was celebrated in 2000, we had misplaced all our institutional knowledge and had to restart Physics Olympics from scratch. Our five-event format is built around a theme and always includes a Do-Ahead, a Plan-Ahead, a Communication-Calculation Challenge, an Impromptu Team Activity, and Fermi Questions. We will present examples of our favorite events for themes such as D.I.Y. Physics, The Science of Supervillans, Pirates of the Bluegrass, or The Year of the Potato. Our hope is that Physics Olympics will re-emerge as a national celebration of doing physics.

BF03: 1:50-2 p.m. Physics Outreach and Community Engagement at Simon Fraser University

Contributed – Sarah Durston Johnson, Simon Fraser University, Burnaby, BC V5A 1S6 Canada; sjohnson@sfu.ca

This talk gives an overview of the public outreach activities of the Department of Physics at Simon Fraser University. Our largest single event with a typical attendance of 700 people is the Science Spooktacular which includes a Halloween-themed demo show and interactive activities for school-aged children. Another popular event is our twice-yearly Girls Exploring Physics workshop for girls in grades nine and 10. These half-day workshops bring girls on campus to engage in hands-on activities and interact with women physics students and faculty at SFU. Other outreach activities include telescope workshops for children, Lasers in Action workshops for grade eight students, Starry Nights sky observing sessions and a collaboration with the TRIUMF Laboratory for Nuclear and Particle Physics to present Saturday morning physics lectures to high school students and the general public. Details about all of these events and how we manage to do all of this on a limited budget will be presented. http://www.physics.sfu.ca/about/outreach

BF04: 2-2:10 p.m. Summer STEM Camps for South Carolina 7th-10th Graders

Contributed – Susan M. Engelhardt, South Carolina Governor's School for Science & Mathematics, Hartsville, SC 29550; engelhardt@gssm.k12.sc.us

Come learn about our STEM summer camps that reach 1500+ rising 7th-10th grade students. These camps are created and delivered by the South Carolina Governor's School for Science and Mathematics (GSSM) Center for Science Education & Outreach. Our summer camp models will be presented, featuring GoSciTech. This is a week-long residential program that has just completed its 25th year, having served 500 students this summer alone. At GoSciTech, university professors teach a week-long course to middle school students in a hands-on, interactive setting.

BF05: 2:10-2:20 p.m. Physical Science Day: Design, Implementation, and Assessment

Contributed – Liang Zeng, The University of Texas-Pan American, Edinburg, TX 78539; zengl@utpa.edu

*Mark Cunningham, Steven Tidrow, Sara Hardage, Hector Leal, The University of Texas-Pan American**

Science coordinators from local school districts have reported their students do not know what physics is about, the wide range of professions physicists qualify for, and thus lack interest in learning physics. Physical Science Day at The University of Texas-Pan American (UTPA), in collaboration with Edinburg Consolidated Independent School District and Weslaco Independent School District, has been designed, developed, and implemented to raise the awareness of physics as a foundation of science, engineering, and technology disciplines and promote students to study in physical science degree programs at UTPA. Through activities including lab experiments and student testimonies, our results show that the event is effective at increasing student knowledge about physics, physical science and chemistry programs as well as in stimulating youth interest toward studying such disciplines at UTPA. Due to the success of Physical Science Day, we are currently expanding the scale of the event to support the participation of other interested school districts.

*Additional co-authors are: Mr. Chris Smith from the Department of Chemistry at UTPA; Mr. Satya Kachiraju, Dr. Edgar Corpuz, Dr. Dorina Chipara from the Department of Physics and Geology at UTPA; Ms. Jessica Salinas, Ms. Doris Mendiola, and Ms. Karen Dorado from the Department of Community Engagement at UTPA; Dr. Maria Luisa Guerra, Assistant Superintendent from ECISD; and Ms. Connie Sinoy, Science Coordinator from WISD.

BF06: 2:20-2:30 p.m. Kinematic Competitions for Classroom Demonstrations and Outreach Events

Contributed – Elliot E. Mylott, Portland State University SRTC, Portland, OR 97201; emylott@pdx.edu

Justin C. Dunlap, Lester Lampert, Ralf Widenhorn, Portland State University

We present three competitions that quantitatively explore key physics principles from mechanics with three fun physical challenges. They have been used in multiple formats and venues including in the mechanics section of Introductory General Physics at Portland State University (PSU) and multiple outreach events both on campus and at local schools by the Science Outreach Society, a student-led PSU group that promotes science literacy in the community. Each competition uses an original, real-time data collecting program, which offers a simple, clear method to demonstrate various physics concepts including: (1) impulse-momentum, (2) center of mass, and (3) kinematics. The user interface, written in LabVIEW, is intuitive to operate and the competitions require only Vernier Force Plates, a Vernier LabQuest, a webcam, and a computer. Each of these activities is readily available and well-suited for audience participation at outreach events or classroom demonstrations.

BF07: 2:30-2:40 p.m. Engaging Families Through Children's Literature, Hands-on Activities, and Online Games

Contributed – Patricia Sievert, Northern Illinois University, NIU STEM Outreach, De Kalb, IL 60115; psievert@niu.edu

Working in an interdisciplinary office of highly creative people has led us to some interesting and engaging outreach activities. One of our newest and more unique ventures is called STEMRead, a program that uses engaging children's books as a springboard for activities and online programming that develops critical thinking skills and introduces STEM concepts including physics. When possible, we involve authors, either in person or in video interviews. We have materials to accompany several young adult science fiction books, but I will focus on our more recent STEMRead Jr.

projects, using Rosie Revere, Engineer as an example. I'll share the videos of the live event as well as videos produced for the online programming, the online game, and related lesson plans for teachers or parents. http://stemread.niu.edu/ http://niu.edu/stem/

BF08: 2:50-3 p.m. Role of Mentors in STEM After-School Programs

Contributed – Anindya Roy, Johns Hopkins University, Materials Science and Engineering, Baltimore, MD 21218-2680; royanin@gmail.com

Michael Falk, Materials Science and Engineering, Johns Hopkins University

Yolanda Abel, Steven Sheldon, Carolyn Parker, School of Education, Johns Hopkins

Kavita Mittapalli, MN Associates, Inc. External evaluator, SABES

More than 60 students, postdoctoral fellows and faculty members from Johns Hopkins University (JHU) participate in the after-school component of the STEM Achievement in Baltimore Elementary Schools (SABES) project (NSF MSP Grant No. DUE-1237992). The after-school program complements in-school STEM teaching, teacher training and support, and community partners involvement in this cross-disciplinary and multi-faceted initiative. In its first year of implementation, SABES operates in three elementary schools in different neighborhoods in Baltimore. Johns Hopkins School of Engineering, Education, and Sociology collaborate with Baltimore City Public Schools administration, schools, and community development corporations to implement SABES. In our presentation, we share feedback from the JHU scholars/mentors regarding their experience and perspectives working with elementary students. Their input provides insights into how best to design mentorship opportunities and build a model for university students in an after-school setting in an effort to increasing outreach and partnership initiatives of universities.

BF09: 3-3:10 p.m. Multidisciplinary Outreach: A Partnership with Math Circle

Contributed – Shawn A. Weatherford, Saint Leo University, Lewis Hall 111, St. Leo, FL 33574-6665; shawn.weatherford@saintleo.edu

Monika Kiss, Saint Leo University

Beginning a physics outreach efforts without an existing framework can appear daunting to the uninitiated. In 2012, I partnered with a mathematician to add physics and engineering activities to an established mathematics outreach program hosted by Saint Leo University called Math Circle. Math Circle is a national movement to provide pre-high and high school students a place to live and love mathematics. At Saint Leo University, Math Circle is structured to run weekly in the late afternoon and includes participants from third grade to 11th grade. This presentation will discuss the goals for these physics outreach activities within the context of the goals of the Math Circle outreach program. The presentation will also provide a reporting of successful activities and the future direction for continued support of combined outreach activities for students with varying mathematical skills.

BF10: 3:10-3:20 p.m. Give Peas a Chance: A Citizen Science Discovery

Contributed – Miranda C P Straub,116 Church St. SE, Minneapolis, MN 55455-0213; pihlaja@physics.umn.edu

The Zooniverse is a suite of online citizen science projects that has provided an opportunity for volunteers to contribute to science and humanities research without requiring extensive training or expertise. It uses crowd-sourcing methods to make independent classifications useful to researchers on the science teams. Since the launch of the first Zooniverse project in 2007, the organization has grown to more than 25 projects and reached the 1,000,000 participant mark in early 2014. While the goal of using volunteers for data processing has been successful, there have been unexpected examples of genuine discoveries by citizen scientists along the way. This talk will focus on the discovery of a class of galaxies called the "Green Peas," which were discovered by Galaxy Zoo volunteers in 2007. I will highlight elements of the scientific research process they used to characterize these as a new class of object, and explain identify common themes that can be used to encourage further serendipitous discoveries in other projects.

Session BG: K-12 PER

Location: Tate Lab 166
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in High Schools
Date: Monday, July 28
Time: 1:30–3:20 p.m.

Presider: Dan Crowe

BG01: 1:30-2 p.m. How Knowledge of Students' Ideas Affects Teaching*

Invited – Michael C. Wittmann, University of Maine, Orono, ME 04469-5709; mwittmann@maine.edu

One joy in teaching physics lies in attending to students' ideas, taking them seriously, analyzing on the fly where they need help, building on what they know, and enabling them to go further than they might have expected. Can the skill of listening to and working with student ideas be taught? As part of two graduate-level courses in physics education research, we emphasize attention to student thinking through analysis of student work, carrying out interviews, and studying classroom video. In this talk, I'll present our course design, evidence of why this approach matters, and some stories by teachers who have gone through our course on the effect it had on their teaching.

*This work is sponsored in part by NSF grants DRL-1222580 and DUE-0962805.

BG02: 2-2:30 p.m. Review of an Integrated Physical Science Course for K-8 Teachers

Invited – Barbara L. Gonzalez, California State University Fullerton, Department of Chemistry and Biochemistry, Fullerton, CA 92834-6866; bgonzalez@fullerton.edu*

Sissi L Li, Michael E Loverude, Roger Nanes, California State University Fullerton

Physics-Chemistry 102, "Physical Science for Future Elementary Teachers" is one of three courses that were developed at California State University Fullerton as part of an NSF-funded initiative to enhance the science content understanding of prospective teachers; the other courses cover geology and biology. PHYS-CHEM 102 is taught in a weekly six-hour integrated lab format, with enrollment limited to 26 students per section, and little or no lecture instruction. The course emphasizes learning science with a strong focus on conceptual understanding, such that teachers will see science as an interconnected discipline with real-world implications, rather than a collection of facts and equations. We will describe the course and its development, present research data illustrating the need for the course and its effectiveness in developing conceptual understanding of physical science. We will also present data from recent efforts to incorporate NGSS and describe future prospects for the course.

U.S. Department of Education FIPSE #P116Z100226

*Sponsors: Daniel Crowe Michael Loverude

BG03: 2:30-2:40 p.m. Analysis of Students' Scientific Creativity in an After-school Physics Program

Contributed – Kathleen A. Hinko, University of Colorado Boulder, 440 UCB, Boulder, CO 80309-0001; kathleen.hinko@colorado.edu

Creativity is the ability to produce work that is both novel and appropriate; without creativity, science does not move forward in meaningful ways. Educational efforts to engage students in authentic physics practices should thus incorporate support for scientific creativity and creative processes. In this talk, I present a framework for characterizing scientific creativity exhibited by K-8 students in an after-school physics program. This framework blends aspects of systems and component creativity along with features specific to physics such as experimental design, problem solving and the nature of science. I apply this framework to the analysis of in situ and interview video data of students as well as student notebooks. Implications for structural and curricular design elements that affect scientific creativity are discussed.

BG04: 2:40-2:50 p.m. Analyzing High School Physics Consensus Discussions: Advantages and Limitations

Contributed – Enrique A. Suarez, University of Colorado, Boulder School of Education Boulder, CO 80309-0249 enrique.suarez@colorado.edu

Philippe J. Guegan, Valerie K. Otero, University of Colorado, Boulder

This study presents a methodology for characterizing the structure and nature of large group discussions in a Physics and Everyday Thinking -- High School (PET-HS) classroom. The PET-HS curriculum was developed to model scientific induction and relies on collaborative discussions to facilitate student sense-making and consensus about the course's learning targets. The analytical framework presented here was designed with the intent of identifying the contributions from teacher, individual student, and groups to the discussions. Specifically, this analysis helps track how different actors are interacting with each other. Two-dimensional and three-dimensional representations are used for highlighting different dialogue patterns. Results yield information on equity of participation, changes in the structure of discussions throughout a class period and school year. By superposing these data with data on the substance of the discussions, we can infer the types of moves that drive the conversation. Implications for running productive discussions and trade-offs will be discussed.

BG06: 3-3:10 p.m. Investigating Interactive Whiteboard Use in a High School Setting

Contributed – Bor Gregorcic, University of Ljubljana, Jadranska 19 Ljubljana, SI: 1000 Slovenia; bor.gregorcic@fmf.uni-lj.si

Eugenia Etkina, Rutgers University

Gorazd Planinsic, University of Ljubljana

The talk will discuss how IWB was used in an advanced way that incorporates students' meaningful creative, graphical, and kinesthetic input as a key part of a learning sequence in a Slovenian high school. We have learned from a previous pilot study in the same school that the IWB is mostly used in a way that does not take advantage of touch technology affordances, but rather mirrors well-established patterns of classic whiteboard use and the use of a computer-projector setup. In our study, two lessons were designed and implemented, one on the topic of Kepler's laws and the other on geometrical optics. We have observed how teachers and students respond to new activities and changes in classroom dynamics. Through in-depth interviews with students and teachers, we have probed their perceptions of the IWB as a learning and teaching tool and perceived benefits and drawbacks of truly interactive IWB use.

BG07: 3:10-3:20 p.m. Building Quantum Mechanics Base Concepts in the Contexts of Polarization and Spin

Contributed – Giacomo Zuccarini, University of Udine, via delle Scienze, n°208, Udine, 33100 Italy; giacomo.zuccarini@uniud.it

Marisa Michelini, Alberto Stefanel, University of Udine

Modern physics and in particular quantum mechanics (QM) is a cultural need for new generation citizens and it will be an official part of the secondary school curriculum starting from next year. Nonetheless, how to teach it is still an open question. Quantum incompatibility as a central feature of the new physical behavior is the goal of a design-based proposal focused on building theoretical thinking in approaching QM in secondary school. In the contexts of polarization and spin, the vector description of the quantum state of a system emerges as interpretative hypothesis in phenomena explored by students. The connection between physical systems and processes on the one side and their formal description on the other side is analyzed by visualizing relations between entities representing system properties and relations between corresponding state vectors. Data on students' reasoning in step-by-step educational intervention modules have oriented the global path proposed.

Session BH: Preparing Physics Teachers to Teach in Diverse Environments

Location: STSS 412
Sponsor: Committee on Teacher Preparation
Co-Sponsor: Committee on Diversity in Physics
Date: Monday, July 28
Time: 1:30–3 p.m.

Presider: Wendy Adams

BH01: 1:30-2 p.m. Physics Teacher Education at Florida International University – A Hispanic-serving University*

Invited - Eric Brewe, Florida International University, Miami, FL 33199; ebrewe@fiu.edu

Florida International University redesigned secondary teacher education programs in 2009. These redesigned programs allow students to earn degrees in physics and become certified teachers upon graduation. Florida International University is the largest source of STEM bachelors and masters degrees for Hispanic students. Thus, the students participating in the FIU physics teacher education program both represent a diverse cultural background and will most likely teach in a diverse community. Two hallmarks of our program are Modeling Instruction and attention to developing communities. In this talk we discuss these two features as they pertain to preparing pre-service teachers for the diverse community of South Florida. As well we look forward to the implementation of FIUTeach as a further evolution of the teacher education programs.

*Supported by NSF 0802184 & FIUTeach

BH02: 2-2:30 p.m. Building on Learner Resources in Urban Pre-service Teacher Professional Development

Invited – Andrea Gay Van Duzor, Chicago State University, Chicago, IL 60628; andrea.vanduzor@csu.edu*

Mel S. Sabella, Chicago State University

Too often in public discourse about urban education deficit thinking predominates with a focus on what students cannot do and the standardized tests that illustrate their failure. Alternatively, new teachers are more effective when they seek to help students build on their intellectual resources and capabilities. As we prepare our pre-service science teachers at Chicago State University, we focus on four elements: inquiry-based learning environments in science, early teaching experiences, explicit attention in pedagogical content knowledge courses on student resources rather than student deficits, and an emphasis on the professional nature of teaching. As a minority serving institution on the South Side of Chicago, our pre-service teachers often have experienced the impacts of deficit thinking in their own educational journeys. Inquiry learning and early teaching experiences build on our science pre-service teachers' resources while simultaneously modeling attitudes for the K-12 classroom.

*Sponsored by Wendy K. Adams

BH03: 2:30-2:40 p.m. Diverse Environments in Northern Colorado K-12 Schools

Contributed – Wendy K. Adams, University of Northern Colorado, Department of Physics and Astronomy, Greeley, CO 80639; wendy.adams@unco.edu

Diversity in Colorado K-12 schools has taken on a new meaning in the past four years. We are no longer merely facing diverse socio-economic backgrounds. 25% of the students in our local district speak English as a Second Language (ESL) and over 10% are recent refuges to America. This past year there were 54 languages spoken in one local high school with many of the students entering school for the first time in their lives. One might think that science teachers would be insulated from many of these challenges, unfortunately various pressures in the school system result in this same diversity in the science classroom. The good news is that techniques that are effective for teaching ESL learners are consistent with techniques for effective instruction in science.

BH04: 2:40-2:50 p.m. High-impact Practices in a Conceptual Physics Course for Future Elementary School Teachers

Contributed – Vazgen Shekoyan, Queensborough Community College, CUNY, Bayside, NY 11361; vshekoyan@qcc.cuny.edu

Anita Ferdenzi, Queensborough Community College, CUNY

According to the Association of American Colleges and Universities, a number of educational experiences are conducive to high-impact learning such as a) Learning Communities, b) Service- or Community-based Learning and c) Writing-Intensive Courses. We have incorporated the above mentioned high-impact practices in a linked Conceptual Physics and Introduction to Education courses for Childhood Education majors at Queensborough Community College. As a learning community, future elementary program where students teach selected physics topics to K-5 mixed-age groups of students. Students' lesson plan write-ups and pre school teachers have to register to both courses concurrently. We have assigned mutually beneficial assignments for further enhancement of the learning community. As part of service learning, we have formed collaboration with a local after-school and post reflection assignments were few of the writing-intensive components of the class. We will discuss the evaluation and implications of our approach in this talk.

BH05: 2:50-3 p.m. Wonder Questions: Eliciting Student Wonder for Knowledge, Inspiration and Motivation

Contributed – Christine Lindstrom, Oslo and Akershus University College, PB 4 St. Olavs plass Oslo, Oslo N-0130 Norway; christine.lindstrom@hioa.no*

Sigurd Løken, Oslo and Akershus University College

Knowledge is unveiled because people ask questions, and their questions unveil what they already know. Since fall 2012, a flipped classroom approach has been implemented in physics courses in Norwegian Science Teacher Education in Oslo. Students complete a short online pre-work module, which includes asking a "Wonder Question" -- anything the student may wonder about that pertains to the topic, such as "How do night vision goggles work"? The purpose is to encourage students to connect new knowledge with previous experience, inspire wonder and help structure class time according to student interests. Some pre-service teachers used Wonder Questions in their own practicums. One teacher received the following Wonder Question from a ninth grader who had learned that energy is conserved: "Can you please tell us a bit about the transformations of energy from the Big Bang until today"? The opportunities for teaching and learning offered by Wonder Questions will be discussed.

*Sponsored by Auysh Gupta

Session BI: Panel – Two-Year College New Faculty Experience: Commencement Conference Update

Location: STSS 330
Sponsor: Committee on Physics in Two-Year Colleges
Date: Monday, July 28
Time: 1:30–3:30 p.m.

Presider: Todd Leif

BI01: 1:30-3:10 p.m. Overview of the New Faculty Experience

Panel – Scott F. Schultz, Delta College, 1961 Delta Rd., Midland, MI 48710; sfschult@delta.edu

The New Faculty Experience for Two-Year College faculty is an 18-month immersion and mentoring program offered to faculty in their first five years of teaching full-time at a two-year college in the United States funded by NSF grant # 1225603. This is the commencement of the third cohort of faculty to go through the experience. The presentation will consist of an overview of the 18-month experience, some statistical data on the participants, and the impact the project is making.

BI02: 1:30-3:10 p.m. Two-Year College New Faculty Experience Participant Evolution

Panel – Aurelian Balan, Delta College, 1961 Delta Rd., University Center, MI 48710-0001; abalan@delta.edu

As a graduate from the 2011 Two-Year College New Faculty Experience (NFE), and a leader in the 2013 NFE, I have observed and interacted from both sides of the experience. The NFE takes two-year college instructors, and teaches them how to engage students with innovative takes on active-learning techniques. Going through the experience as a participant, the impact on my instruction style was significant and beneficial. As a leader working with the next set of new faculty the following year, I was able to observe others experiencing the same transformation. I will elaborate on the impact this had on my teaching techniques. Material and techniques from both conferences will also be shared.

BI03: 1:30-3:10 p.m. A Thousand Choices: Deciding Between Teaching Strategies

Panel – Ian Freedman, Dutchess Community College, Poughkeepsie, NY 12601-1595; ifreedman@hotmail.com

A Thousand Choices: If you're new to teaching or simply looking for new teaching strategies, you might have come across many different methods of active teaching. This presentation discusses some of the options you'll encounter and how to sort through the different options to find a teaching strategy that works well for you and your students.

BI04: 1:30-3:10 p.m. Experiences and Challenges Implementing Active Learning Techniques

Panel – Leilah McCarthy, City College of San Francisco, 50 Phelan Ave., San Francisco, CA 94112; lmccarth@ccsf.edu

During the March 2013 TYC-NFE workshop, I learned several teaching techniques to get students more engaged in class. I left very excited to try these out in my classes. While these changes have completely transformed by classes, there have been challenges, especially pertaining to class size, classroom architecture, and lack of administrative support. In this talk, I will describe these challenges and why, despite the challenges, I would never go back to a traditional lecture.

BI05: 1:30-3:10 p.m. Development of an Interdisciplinary Nanotechnology Laboratory

Panel – Becky L. Treu, Moberly Area Community College, Advanced Technology Center, Mexico, MO 65265; beckyt@macc.edu

Michelle Scanavino, Moberly Area Community College

Many programs and institutions have made great advances in developing a variety of interdisciplinary approaches, but systemic progress has been slow. The increasing complexity of science demands that concepts and methods from different disciplines be merged. In this multidisciplinary lab students in General Chemistry I employ redox reaction knowledge and wet chemistry techniques to fabricate silver nanoparticles while students in Foundations of Physics employ knowledge of color/light and quantum theory to characterize the nanoparticles. Students in Microbiology receive the characterized nanoparticles and test for their antimicrobial properties in e.coli streak plates. The goal of this laboratory is for students to understand that science takes time and builds on multiple concepts. It is also crucial for students to understand the importance of having strengths in multiple disciplines. Many of the most interesting and important problems in science can be answered only through collaborative efforts.

BI06: 1:30-3:10 p.m. Interactive Lecture Demonstrations with Video Analysis

Panel – Nathan A. Quarderer, Northeast Iowa Community College, Calmar, IA 52132; quarderern@nicc.edu

The lecture demonstration has long been part of the standard introductory-physics curriculum. Only within the last 15 years has an emphasis been placed on engaging the student throughout the process in an attempt to make the demonstration as interactive as possible. Video analysis has also been widely used to help supplement physics instruction, though has historically required cumbersome apparatus and additional software potentially making it a less accessible option. With the advent of smart phones and the technology that comes along with them, the tools required to perform simple video analysis are now at our fingertips. I have adapted several traditional lecture demonstrations to incorporate video analysis, and help engage the student in a truly interactive process.

BI07: 3:10-3:20 p.m. Modifying Just-In-Time-Teaching to Encourage Student Reflection

Contributed – Andrew Morrison, Joliet Junior College, Joliet, IL 60431-8938; amorrison@jjc.edu

Just-in-time-teaching (JiTT) is a teaching and learning strategy where a feedback loop is created between instructor and students in order to focus classroom activities toward concepts the class is having the most difficulty in understanding. Two important components of a JiTT strategy are short exercises done outside of class and the response to the exercises in class. In previous physics courses, my students have been assigned readings to complete as well as questions to answer online based on assigned readings. The instructor is responsible for reading student responses before the start of class and has the opportunity to adjust class activities to address concerns raised by students in their answers. This year, I modified the JiTT method to encourage student reflection on the activities completed in class and emphasize critical reading skills. The benefits and challenges of the JiTT method and present modifications are discussed.

BI08: 3:20-3:30 p.m. TYC Leadership Institute: An Introduction to Leadership Development

Contributed – Brooke Haag, American River College, Sacramento, CA 95841; HaagB@arc.losrios.edu

Informed by the principles of the Project Kaleidoscope (PKAL) Summer Leadership Institute, this workshop was conceived to involve two-year college (TYC) physics faculty in experiential learning exercises to foster leadership skills. The workshop addressed a range of skills from effective communication to work-life balance via interactive activities and moderated discussions. In this talk, the framework of the institute will be detailed. Outcomes and future plans will also be discussed.

Session BJ: Physics of Phun

Location: STSS 114
Sponsor: Committee on Physics in High Schools
Date: Monday, July 28
Time: 1:30–2:20 p.m.

Presider: Diane Riendeau

BJ01: 1:30-1:40 p.m. A Case Study Using Extracurricular Activities for Interactive Physics Engagement

Contributed – Devin Rourke, University of Colorado, Boulder, Boulder, CO 80303; devin.rourke@colorado.edu*

Extracurricular activities are valuable elements in a high school student's daily routine--they effectively teach the social, moral, and behavioral hidden curricula often missed in a traditional classroom. Still, these commitments crowd a high school student's schedule and add unmanageable stress, which threatens both their traditional academic performance and their overall health and well-being. Therefore, it is worth examining ways in which to academically engage students in the low-pressure, fun environment that extracurriculars provide. This report, and the workshop titled "The Physics of Sports" described herein, demonstrate that the pedagogy of informal science education through extracurriculars has many benefits aside from simply stress reduction. These benefits include active and interactive engagement, social learning, promoting personal identity, situated cognition, the role of play, and anthropomorphic epistemology, to name a few. We explore the existing opportunities, necessary conditions, and practical challenges in using extracurricular activities as an effective tool for cognitive development.

*Sponsored by Dr. Kathleen Hinko and Dr. Noah Finkelstein (University of Colorado Boulder Physics Education Research). Special thanks to Dr. Emily Haynes (Centaurus H.S., Boulder Valley School District).

BJ02: 1:40-1:50 p.m. Back in the Day

Contributed – Diane M. Riendeau, Deerfield High School, Lake Zurich, IL 60047; dianeriendeau1@gmail.com

As electronic toys and games become more the norm, students have fewer experiences with the hands-on toys from "back in the day." What we remember from our childhood is a new experience for many of today's students. I will present several of these "old fashioned" toys that I have collected through the years and explain how I use them to teach a variety of physics concepts.

BJ03: 1:50-2 p.m. Getting Students Excited About Science with High Altitude Ballooning

Contributed – Charles Niederriter, Gustavus Adolphus College, St Peter, MN 56082; chuck@gac.edu

Steven Mellema, Gustavus Adolphus College

James Flaten, University of Minnesota

Many of us dream of exploring space, but there are not many ways to do so. Although it is difficult to get into deep space, near space is within our grasp. High-altitude balloons are released into the stratosphere, generally reaching between 60,000 to 120,000 feet before they burst and their payload is returned to Earth by parachute. Modern balloon systems generally contain electronic equipment such as radio transmitters, cameras, and GPS receivers, as well as a variety of scientific instruments. Not only is high-altitude ballooning a great way to introduce the electronics and programming skills needed to collect and analyze data from the spacecraft, it provides a fun way to explore scientific concepts from pressure, temperature and volume to cosmic radiation. We have begun offering summer camps to high school students in order to capitalize on the excitement of ballooning to get them interested in physics.

BJ05: 2:10-2:20 p.m. Use of NYTimes Sports Section To Help Teach Physics

Contributed – John P. Cise, Austin Community College, Austin, TX 78701; jpcise@aol.com

The New York Times Sports section is usually rich with physics concepts (Kinematics, projectiles,Newton's second, Work,Energy, etc). Over the past six years I have developed a NYTimes Physics Applications site using news articles rich in Physics applications. http://CisePhysics.homestead.com/files/NYT.htm. Articles and graphics are copied into Word, edited to fit on one page with: Introduction, Questions, Hints and Answers. The author uses these one page web applications for: Introduction to concepts, quizzes, and student extra credit. My presentation will feature some NYTimes Sport section articles rich in physics applications. http://CisePhysics.homestead.com/files/NYT.htm

Session BK: Making Physics Phun

Location: STSS 114
Sponsor: Committee on Physics in Two-Year Colleges
Date: Monday, July 28
Time: 2:30–3:20 p.m.

Presider: Paul Williams

BK01: 2:30-2:40 p.m. Juggling Physics and Phun

Contributed – John P. Lewis, Glenbrook South High School, Glenview, IL 60026; jlewis@glenbrook225.org

Part of the "Phun" of juggling is the beautiful way it can be described with simple physics explanations. I'll be demonstrating and explaining the physics of "Bounce Juggling" in particular. This type of juggling lends itself to an elegant discussion of the application of each of Newton's three laws of motion in a qualitative, non-threatening way. For those who desire a bit more rigor, our discussion will extend to applications of rotational physics as well.

BK02: 2:40-2:50 p.m. Making Physics Phun in Two-Year College

Contributed – Madhuri Bapat, Eastern Arizona College, Thatcher, AZ 85552; durga1950@hotmail.com

I would like to share an account of physics programs that I have developed for the last 15 years at a two-year college in a small rural community in Arizona. We offer physics at three levels—conceptual physics, college physics-algebra based, and university physics-calculus based—all taught by me for over 10 years. Students are catered to their levels by adding innovative lab activities and projects to the curriculum. The enrollment has doubled in 10 years as a result of many additional out of classroom activities such as an outreach program, physics club, model rocketry and robotics classes. Many success stories will be shared in the presentation. This author emphasizes love and enthusiasm for physics and laid-back personality of instructor along with providing relaxed and cooperative atmosphere in the classroom while teaching and learning.

BK03: 2:50-3 p.m. Promoting Phun in Conceptual Physics: Physics in Movies and Everywhere

Contributed – Doris Jeanne Wagner, Grove City College, Grove City, PA 16127; djwagner@gcc.edu

Emily Hare, Grove City College

In the spring of 2013, our department re-evaluated the one-semester survey conceptual physics course we offer as part of our core curriculum. Based on feedback from students in the course, we added a very successful "Physics of Movies" component starting in fall 2013. I also added a discussion board, "There's Physics in That" in the fall offering, in which students posted on where they had seen physics outside of the classroom and commented on classmates' posts. Many students fully embraced the spirit of this activity, and excellent online discussions took place. This talk will summarize my efforts in the class and describe the results of assessment.

BK04: 3-3:10 p.m. Science Through Film and Fiction: Teaching Science with Virtual Reality

Contributed – Derin A. Sherman, Cornell College, West Mount Vernon, IA 52314; dsherman@cornellcollege.edu

When a student creates a virtual world, she also explores the scientific method. She can perform a wide array of scientific experiments, build and refine theoretical models, make detailed measurements, and test hypotheses. In Greg Egan's novel "Permutation City," the characters design and debate the scientific laws that will be used to create a complete virtual world where "copies" of humans will live their lives. Egan's characters also explore some of the more abstract ideas in physics, including the multiverse theory. Through their reading and virtual lab work, students learn that science is a creative process used to construct and improve theoretical models that approximate reality. In this presentation, I will show how science fiction and virtual reality can be used to effectively teach students about science. All software used is free and will run on both Macintosh and Windows platforms.

BK05: 3:10-3:20 p.m. Taste and See that Physics Is Fun

Contributed – Michael J. Ponnambalam, St. Xavier's College, 7 - 40 Sannathi St., Tamil Nadu, TN 627116, India; michael.ponnambalam@gmail.com

Communicating the fun, enjoyment and excitement in physics to the students, or to the general public, becomes a bit easier when the presenter himself/herself has enjoyed the fun in physics, and has a passionate love for physics as well as an infectious enthusiasm. Further, when the presenter dramatizes the events in the presentation, clarifies complex concepts using familiar examples from daily life, makes inert numbers come alive using an appropriate metamorphosis, and motivates the students using inspirational quotations and auto suggestions, the audience finds it easier to taste and see that physics is fun. The author's experience in this connection in different countries will be presented.

Session TOP05: iOS and Android App Show

Location: STSS 131B
Sponsor: Committee on Educational Technologies
Date: Monday, July 28
Time: 4–5:30 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 "Show and Tell" for a cavalcade of apps—both "student" and "teacher" apps are welcome. Each presenter will get five minutes to show their app. You can sign up at the show or, to ensure you get time, you can sign up in advance at http://ncnaapt.org/appshow (this will also help us to avoid duplication). We'll have dongles to connect iPad/iPhones to the projector, and maybe some Android devices, but since devices have different connectors we suggest bringing your own (if you have one), and we'll also have a document camera to project any device that we can't connect. A list of all apps presented will be available to those who attend and those who can't.

Session CA: Panel – Educational Technology Highlights from MPTL

Location: STSS 330
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on International Physics Education
Date: Monday, July 28
Time: 4–6 p.m.

Presider: Wolfgang Christian

Multimedia in Physics Teaching and Learning (MPTL) conferences have been organized annually since 1996 by a European-based multidisciplinary group of teachers and researchers who implement and study the uses of computers in the teaching of physics. Recent topics at MPTL meetings include simulation and modeling tools, Arduino interfacing, virtual and remote laboratories, augmented reality, interaction with Course Management Systems, and simulations for mobile devices such as tablets. The target population is undergraduate and high school students and instructors. This session presents selected MPTL speakers from non-U.S. countries to contribute to an international exchange of ideas and technology.

CA01: 4-6 p.m. Create Your Own Physics Simulations for Tablets Using EasyJava (script) Simulations

Panel – Francisco Esquembre, Universidad de Murcia, Facultad de Matematicas - Campus de Espinardo, Murcia, Non US 30071 Spain; fem@um.es*

Felix J. García-Clemente, Universidad de Murcia

We introduce a major version of the successful Easy Java Simulations modeling tool that allows physics teachers to create, share, and distribute Java simulations with a very affordable level of training. This backwards-compatible, new release of EJS, now renamed EjsS, is also able to create simulations that run in HTML-enabled browsers, using algorithms written in Javascript. This means that simulations created with this new version of EjsS can run in virtually any computer or mobile platform, including smartphones and tablets. And the level of difficulty for the author remains the same. We have also created a Reader App for Android and iOS that allows a user to collect and organize a number of such simulations for use with students, on- or off-line. When online, the Reader App connects to the OSP collection at the comPADRE digital library, for the download of additional ready-to-use, tablet-enabled simulations.

*Sponsored by Danny Caballero

CA02: 4-6 p.m. Multimedia Learning with Remote Labs and Virtual Experiments

Panel – Raimund Girwidz, Ludwig-Maximilians-University, Munich, Theresienstr. 37 München, DE 80333 Germany; girwidz@lmu.de

Remote laboratories and virtual experiments can promote discovery-learning. Online experimental opportunities with real instruments in combination with supplementary simulations offer new possibilities for learning. From a pedagogical point of view, the direct combination of experimental studies with simulations and additional guidance is essential to contextualize learning, connect with theoretical reflection and thereby promote a deeper understanding. The following theoretical considerations are included: a) Offer additional representations to visualize essentials, b) support the development of mental models and link abstract concepts with realistic examples, c) use special features to promote "cognitive flexibility", d) use illustrations to structure knowledge, e) ensure a sufficient depth of processing f) avoid cognitive overload by sequencing information. Also some findings from empirical studies will be discussed, showing factors and conditions that are important to reach these goals.

CA03: 4-6 p.m. Multimedia in Acoustics

Panel – Leopold Mathelitsch, Inst. Physics, Univ. Graz Univ.platz 5 Graz, Styria A-8010 Austria; leopold.mathelitsch@uni-graz.at

Visualization of acoustical phenomena can be regarded as true multimedia: Acoustical input is analyzed by electronic means and the results can be presented simultaneously and also interactively in a graphical way. It is obvious that this possibility also has substantial didactical value. For this purpose hard- and software have been developed concerning different aspects of acoustical phenomena. The European MPTL group and the American MERLOT consortium joined in a worldwide evaluation of available software on acoustics, leading to recommendations of "best" products with regard to physical content and pedagogical value. The contribution gives an overview of this evaluation procedure and presents examples exhibiting the richness of the acoustical world. These include investigations of sound taken from our technical and natural surroundings and analyses of musical instruments culminating in the most valuable one, the human voice.

CA04: 4-6 p.m. Using Moodle to Design Physics Online Courses with Virtual and Remote Laboratories Based on EJS

Panel – Luis De La Torre, UNED, Calle Juan del Rosal, 16 Madrid, Madrid 28040 Spain; ldelatorre@dia.uned.es

Ruben Heradio, Jose Sanchez, Sebastian Dormido, UNED

Easy Java Simulations (EJS) helps to create interactive simulations in Java, mainly for teaching and learning purposes. By means of this tool, instructors can easily create virtual and/or (if they also use the appropriate additional software) remote laboratories. Learning Management Systems (LMS) are software for web applications oriented for the administration, documentation, tracking, and reporting of e-learning programs. Moodle is a free source LMS with more than 60 million users, which makes it the most used LMS around the world. Like some other LMS, the stated philosophy of Moodle includes a constructivist and social constructionist approach to education, emphasizing that learners (and not just teachers) can contribute to the educational experience. Virtual and remote laboratories (created with EJS, for example) as well as LMS (Moodle, for example) offer different but fundamental educational tools to both teachers and students. However, although these resources are complementary (and not mutually exclusive), the integration between them is still an open issue that must be addressed. Therefore, an e-learning program should offer both kinds of tools to be considered a complete experience for students. The EJSApp add-ons for Moodle gather together the two previous resources, offering the possibility to build and prepare e-learning programs based on: 1) experimentation (thanks to the use of the virtual and remote laboratories) and 2) theory documentation provision, social interactivity and easy management (thanks to the use of the LMS).

CA05: 4-6 p.m. High-Speed-Video Learning Path on Complex Fluids: From Physical Laws to Cutting-edge Applications

Panel – Peppino Sapia, University of Calabria, Ponte Bucci, cubo 31/C Rende, 87036 Italy; peppino.sapia@fis.unical.it

Video analysis of Newtonian and non-Newtonian fluids phenomenology provides to the physics teaching/learning process an extremely rich and exciting context to convey concepts, issues and methodologies concerning either traditional physics of fluids or cutting-edge research on materials properties. In this connection, a multimedia learning path is presented, based on high-speed and/or high-resolution video imaging of selected phenomena, easily reproducible in a teaching laboratory. The use of commercial grade photo/video cameras, together with freely available video analysis software, allows learners to explore unfamiliar phenomena related to fluids (such as viscoelasticity and super-hydrophobicity), allowing them to get in touch with the principal theoretical concepts and practical applications pertaining a context located at the boundaries among physics, chemistry and biology. The learning path, aimed to students of high school's last year or university undergraduates, presents both an illustrative character (aimed to capture the attention of learners) and more deep quantitative features, giving students and teachers methodological and practical hints to independently conduct and analyze their own teaching experiments. Moreover, presented activities and documental materials give teachers significant examples of the role of video-analysis either in education or in empirical research.

Session CB: Incorporating Metacognition in Physics Instruction and Assessing Outcomes

Location: STSS 220
Sponsor: Committee on Research in Physics Education
Date: Monday, July 28
Time: 4–6 p.m.

Presider: Mila Kryjevskaia

CB01: 4-4:30 p.m. Scientific Articles and Metacognition – Enhancing Students' Understanding

Invited – Yehudit Judy Dori, Massachusetts Institute of Technology, Cambridge, MA 02139-4307; yjdori@mit.edu

Reading scientific articles is a vital part of communicating scientific knowledge to high school and undergraduate students, our future citizens, for preparing them to be independent life-long learners. Reading is an active process, which demands constructing new knowledge and linking it to prior knowledge. We have demonstrated the importance of training students in applying a metacognitive tool for facilitating students' reading and analyzing scientific articles. The tool guides students how and when to use various reading strategies and monitor their own understanding of scientific texts. In my talk, I will refer to the metacognitive aspect of scientific literacy and describe two metacognitive studies, one conducted with high school chemistry majors and the other with bio-medical undergraduate students. Finally, I will discuss the implications of these studies to science education in general and physics education in particular.

CB02: 4:30-5 p.m. Guiding and Gauging Students' Reflective Metacognition*

Invited – Andrew Boudreaux, Western Washington University, Bellingham, WA 98225-9164; andrew.boudreaux@wwu.edu

Historically, physics education research has guided development of instructional strategies that significantly boost conceptual understanding. Recently, efforts have expanded to more implicit instructional goals, such as promoting expert-like views about what must be done to learn new physics ideas. Progress in promoting the "hidden" curriculum has been slow: most pre/post measurements have in fact yielded negative gains. At Western Washington University, we are exploring ways of promoting student reflection, a backward-looking form of metacognition.* Experts somehow develop the conscious habit of reviewing what they have learned and checking for gaps in their understanding, but what can be done to hurry the process along? In the context of a lab-based reflection activity, we have collected written and video data, with twin goals of guiding modification to the instruction and contributing to the knowledge base on student metacognition. This talk will describe the instructional approach and illustrate specific modes of student reflection.

*Work supported by NSF DUE-1245993.

CB03: 5-5:30 p.m. Epistemic Impact on Metacognition in Cooperative Group Problem Solving[1]

Invited – Andrew Mason, University of Central Arkansas, Lewis Science Center, Conway, AR 72035-0001; ajmason@uca.edu

Charles Bertram, Cassandra Lange, University of Central Arkansas

Cognitive apprenticeship for physics problem solving has been demonstrated to show potential for students to reflect upon their problem solving attempts. In the context of introductory physics for life sciences (IPLS), a concern exists that non-physics science majors may have attitudes towards physics that mitigate the efficacy of a metacognitive problem solving exercise. A weekly metacognitive intervention adapted from Yerushalmi et al. (2012) was administered in a lab group problem solving setting for a first semester algebra-based introductory physics course. MPEX and CLASS surveys were used in a pre-post format for respectively the fall 2013 and spring 2014 semesters. Other forms of data include written artifacts from the students themselves about aspects of problem solving with which they struggled, as well as an end-of-semester survey about the usefulness of the exercise. We discuss the effectiveness of the reflection task with respect to the students' attitudes towards problem solving.

1. E. Yerushalmi, E. Cohen, A. Mason, and C. Singh (2012), *Phys. Rev. ST-PER* **8**(2), 020109 and 020110. (two papers)

CB04: 5:30-6 p.m. Metacognitive Intercessions in Student Conceptions

Invited – Adam Johnston, Weber State University, Ogden, UT 84408-2508; ajohnston@weber.edu

Eric Amsel Weber State University

Research in conceptual change is clear: Students cannot simply process information, but must also actively reflect upon and contrast it to what they already know, even when the preexisting knowledge isn't well articulated to them. Our work sets up various prompts before asking conceptual questions to see if we can activate student metacognition, as well as to see the extent to which these activations change student responses to such questions. In particular, we prompt students to consider how an expert in the field would respond to particular questions, or how students themselves would respond to the same prompts when considering different characterizations of what they know (e.g., "belief" vs. "knowledge"). Our work compares these strategies in introductory physics courses to introductory psychology courses to further examine the kinds of metacognitive skills and misconceptions students have in different disciplines.

Session CC: Panel – The Work of the Undergraduate Curriculum Task Force

Location: Tate Lab 133
Sponsor: Committee on Physics in Undergraduate Education
Date: Monday, July 28
Time: 4–6 p.m.

Presider: Ernie Behringer

The AAPT established the Undergraduate Curriculum Task Force (UCTF), in part, to develop specific, multiple recommendations for coherent and relevant undergraduate curricula. Please join your colleagues during this discussion to hear a brief summary of the work of the UCTF and to discuss significant curricular issues, including content, implementation, and assessment with UCTF members.

Panelists:

Andrew Gavrin, Indiana University - Purdue University Indianapolis
Joseph Kozminski, Lewis University, Romeoville, IL
Beth Cunningham, American Association of Physics Teachers

Session CD: Perspectives in Particle Physics

Location: STSS 312
Sponsor: Committee on Physics in High Schools
Date: Monday, July 28
Time: 4–5:30 p.m.

Presider: Ken Cecire

CD01: 4-4:30 p.m. The Future of Particle Physics Outreach and Education

Invited – Daniel Cronin-Hennessy, University of Minnesota, Minneapolis, MN 55455-0213; hennessy@physics.umn.edu

Particle physics is more compelling than ever due to the excitement from the discovery of the Higgs boson and other boundaries broken by the Large Hadron Collider at CERN as well as the ongoing mysteries of neutrino physics, dark matter, and dark energy. Much of this story has yet to be told to the public and in our schools. Last summer, the Community Summer Study was held at the University of Minnesota to chart a recommended course for the particle physics community in the U.S. in the coming years. Among these recommendations was a robust program of education, outreach, and public engagement. We will examine these recommendations and discuss what they mean for physics education.

CD02: 4:30-5 p.m. High School Students Exploring the World of Particle Physics

Invited – Shane Wood, Irondale High School, 2425 Long Lake Road, St. Paul, MN 55112; shane.wood@moundsviewschools.org

With the 2012 discovery of the Higgs boson at the Large Hadron Collider (LHC) in addition to the popularity of the television sitcom "Big Bang Theory," many high school students today have at least heard of CERN, the LHC, and the Higgs boson. Students are often excited by the cutting-edge nature of this research and may wonder how it relates to topics studied in their introductory physics class. This talk will focus on opportunities for high school teachers and students to investigate the world of quarks and leptons using real data from the LHC through particle physics masterclasses and e-Labs, while covering required standards, including many Next Generation Science Standards (NGSS).

CD03: 5-5:10 p.m. Merging Innovative Particle Physics Activities with Project-based Learning

Contributed – Evelyn D. Restivo, Global STEM Early College High School, Waxahachie, TX 75165; erestivo2001@yahoo.com

A presentation designed to highlight several projects merging the innovations associated with detectors and the LHC that allow students to merge experimental developments in physics with basic concepts. Project Based Learning provides a way to model and analyze particle motion, use magnetic tracker models, observe collisions of particles, demonstrate counting, compiling data, and calculating the rate of Cosmic Rays from a detector, plus determining the fluidity and number of collisions that indicate the presence of the Higgs Boson. Research has shown that using Project Based Learning improves retention and that using the spectacular physics events of the LHC will raise awareness in modern science and fundamental research, provide experiences that will help motivate students to understand the physical world which in turn will increase scientific literacy, and provide an avenue to develop the interest of mystery, awe, and discovery potential in science, especially physics, for all learners.

CD04: 5:10-5:20 p.m. Connecting Secondary Classrooms in ND, SD, and MN to Tell the Neutrino Story

Contributed – David M. DeMuth, Valley City State University, Valley City, ND 58072; david.demuth@vcsu.edu

Peggy Norris Sanford, Underground Research Facility

Utilizing the high-bandwidth networks in which K-12 institutions are connected, we will describe an overview and status of a project that will simultaneously connect classrooms in North Dakota, South Dakota, and Minnesota to tell the neutrino story. Middle and high school teachers receive professional development on hands-on STEM strategies, lessons are developed using the Next Generation Science Standards, implemented, and then the teachers act as co-facilitators for a simultaneous classroom event that focuses on neutrino production at the Fermi National Accelerator Laboratory, detecting neutrinos at the MINOS experiment at the Soudan Underground Laboratory, at the NOvA detector in Ash River, MN, and finally at SURF in Lead, SD, where STEM careers will be emphasized in conversations that will occur with lead scientists at each location. See more at http://www.stem.vcsu/aapt/.

CD05: 5:20-5:30 p.m. Higgs Boson, Future Discoveries on the Updated CPEP Particles Chart

Contributed – Gordon J. Aubrecht, Ohio State University at Marion, 193 North Washington St., Delaware, OH 43015-1609; aubrecht.1@osu.edu

The Contemporary Physics Education Project's first chart on fundamental particles and interactions and its updates currently grace the walls of a great number of physics departments and many high school classrooms. This talk presents the latest, post-Higgs version of our chart, originally developed about 25 years ago when a group of physicist-educators realized that we had a consensus theory--the Standard Model--that could excite interest in physics in both teachers and students. New features include the latest parameters for the Higgs and neutrino masses, background information, looking at future discoveries, and, of course, our beautiful and amazing graphics.

Session CE: Art and Science of Teaching

Location: STSS 230
Sponsor: Committee on Physics in Undergraduate Education
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 28
Time: 4–5:30 p.m.

Presider: Andy Gavrin

CE01: 4-4:30 p.m. The Knowledge-Practice Gap in Physics Teaching: How Big Is it and Why Does it Exist?*

Invited – Charles Henderson, Western Michigan University, Kalamazoo, MI 49008-5252; charles.henderson@wmich.edu

Although many people consider teaching to be an art, the Physics Education Research (PER) community has shown that there are many aspects of teaching that can be systematically studied and improved using scientific methods. PER has also shown that a wide variety of teachers can consistently improve student learning by using research-based teaching practices. Like most fields, though, there is a substantial gap between the research-based knowledge that PER has developed about effective teaching and the actual practices of physics teachers. In this talk I will use data to describe how large this gap is and identify some of the reasons that the gap exists. Although I will touch on many aspects of this problem, I will emphasize some specific leverage points that may be productive to focus on in order to reduce the gap.

*Supported, in part, by NSF grant #1122446.

CE02: 4:30-5 p.m. MOOC-ing Around: This Is Not the Future

Invited – Charles H. Holbrow, Massachusetts Institute of Technology, Cambridge, MA 02139-4510; cholbrow@mit.edu

I have taken 12 (completed five) MOOCs (Massive Open Online Courses)—cryptography, philosophy, the ancient Greek hero, Puritan poetry, science and cooking, engineering dynamics, and six introductory physics courses—and I have worked for seven months on John Belcher's team creating and adapting MOOC materials for teaching introductory physics at MIT. I will draw on this experience to say what looks good in MOOCs; what does not; why MOOCs are not the future; and why I think higher education will be transformed by low-cost efforts of teachers in smaller institutions including community colleges and high schools. Also I think that to provide reliable certification of student online achievement and reliable evaluation of the quality of online content and its delivery, academic entrepreneurs will create new testing and rating organizations that are independent of content deliverers. Separation of certification from delivery will be a disruptive change in higher education.

CE03: 5-5:30 p.m. MOOC 101: How to Create and Teach a MOOC

Invited – Saif Rayyan, MIT, Cambridge, MA 02139-4307; srayyan@mit.edu

John Belcher, David E. Pritchard, MIT

As a physics teacher, you might have many questions about MOOCs, and what it takes to create and teach one: How to start planning? How to design the course? How do you create content for the course? What types of assessment are available? Who is taking these courses, and what are they interested in? What level of involvement do you expect to have with students? How much time should you expect to spend on creating and running a MOOC? How is teaching a MOOC different from teaching an on campus course? I will attempt to answer some of these questions, highlighting some of the good practices in creating and running MOOCs. I will use examples from the MIT physics department MOOC offerings on the edx platform (http://www.edx.org): 8.01x, 8.02x and 8.MReV.

Session CF: Physics and Society: Current Topics in Energy

Location: Tate Lab 166
Sponsor: Committee on Science Education for the Public
Date: Monday, July 28
Time: 4–5:30 p.m.

Presider: John Welch

CF01: 4-4:30 p.m. Traditional Utility Busines Models and What Challenges/Opportunities Lie Ahead as Sustainable Resources are Added to the Power Grid.

Invited – David J McMillan, ALLETE, Inc., 30 W. Superior St., Duluth, MN 55802; dmcmillan@allete.com

Sustainability, reliability, quality of life, affordability, local self-reliance and technological empowerment are all themes that come to mind when thinking about the electric energy sector and how it will evolve in coming decades. Minnesota Power serves the largest industrial customers in the state and also serves most of the communities across northeastern and north central Minnesota. In 2005, the company served those customers with a generation fleet that was 95% coal and 5% renewable. Today, it serves those customers with a 25% renewable resource mix and is headed for 1/3 of its capacity being renewable within a decade. This presentation will focus on how traditional utility business models are evolving and what challenges —and opportunities— lie ahead for utilities and their customers as more sustainable and more distributed resources are added to the power grid.

CF02: 4:30-5 p.m. Electric Utility Resource Planning in Today's Environment

Invited – Brian H. Draxten, Otter Tail Power Company, 215 S. Cascade St., Fergus Falls, MN 56538; bhdraxten@otpco.com

Resource planning for an electric utility used to be easy: Give customers all the electricity they want, when they want it, at the lowest possible price. Today, utilities need to balance the interests of rate impact, system reliability, environmental concerns, regulatory and legislative policy, and company shareholders. Least-Cost Planning has now become Public Policy Planning. How does a utility balance keeping the lights on (system reliability) with all of the other considerations above when making generation resource decisions? These decisions involve not only new generation sources but decisions on what to do with existing generation sources as well: Traditional dispatchable generation (nuclear, coal, and natural gas) vs. intermittent renewable sources (wind, solar, and biomass) vs. energy efficiency and demand-side management. Diversity is the key.

CF03: 5-5:30 p.m. Energy, Environment, and Economics of the Electric Car

Invited – Richard E. Flarend, Penn State Altoona, 3000 Ivyside Park, Altoona, PA 16601 ref7@psu.edu

After just three years of sales, more than twice as many electric plug-in vehicles have been sold compared to the first three years of hybrid vehicles. If this trend continues, even a small college may have dozens of electric cars requiring a campus public charging infrastructure. The economics of the electric car will be presented showing that they are the least costly vehicles to own and have lower emissions than any other form of transportation even when the generation of electricity is considered. Installation requirements, economics, and regulatory concerns of public charging stations will also be presented. Due to the "limited" driving range and charging time, electric vehicles may not be for everyone. Learn what real-world single-charge and daily driving ranges can be expected from an electric vehicle as well as the effects of extreme temperature.

Session CG: Translating Teachers' Research Experience into Classroom Practice

Location: STSS 412
Sponsor: Committee on Teacher Preparation
Date: Monday, July 28
Time: 4–5:50 p.m.

Presider: Dimitri Dounas-Frazer

CG01: 4-4:30 p.m. Real World Practices in a High School Classroom

Invited – Jamie Vargas, 5375 E Tower Ave., Fresno, CA 93725; vargasjamieh@yahoo.com

The idea of "those who can do; and those who can't teach" is a common saying in the general public, but what if you could "do" and teach at the same time? As an early career teacher I have had the opportunity to not only do science but also to teach students how science is done in the "real world." In this talk I will provide a brief description of my summer research experience at NASA's Jet Propulsion Laboratory through the STEM Teacher and Researcher (STAR) Program. I will also provide some examples on how this experience can be implemented into classroom practice under the guidance of the Next Generation Science Standards.

CG02: 4:30-5 p.m. Design and Implementation of Practice-centered Physics Courses with The Compass Project

Invited – Ryan Olf, University of California, Berkeley, 366 Le Conte Hall, Berkeley, CA 94720-7300; ryanolf@berkeley.edu*

Derrek Coleman, University of California, Berkeley

The Next Generation Science Standards establish Science Practices as the context in which students learn Core Ideas and Crosscutting Concepts, claiming, "students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined." This interplay of science practice and content knowledge may seem foreign to individuals whose experience learning science has centered primarily around classrooms, but to science researchers it is undeniable. In this talk, we discuss how the process by which researchers approach new problems can inform the design and implementation of student learning in the classroom, with emphasis on examples from courses developed by The Compass Project at UC Berkeley for freshman and transfer students. In addition to serving students intellectually, The Compass Project's practice-centered courses help its students develop a supportive community, confidence, curiosity, and connections---key ingredients for long-term success in science.

*Sponsored by The Compass Project and the College of Letters & Science, University of California, Berkeley

CG03: 5-5:30 p.m. Preparing Students for Authentic Research Experiences Through Laboratory Courses

Invited – Heather Lewandowski, JILA CB 440, Boulder, CO 80309; lewandoh@colorado.edu

Preparing undergraduate physics majors for future careers in experimental science is one of the main goals of our current physics education system. At the University of Colorado, we have been working to transform our upper-division laboratory courses to better prepare students for future undergraduate, industrial, or graduate experimental work. Through this process, we have developed learning goals, curricular materials, and assessments for two upper-division lab courses. The transformation process and measured outcomes will be presented.

CG04: 5:30-5:40 p.m. Lab Notebooks: Adapting a Researcher's Approach for the Classroom

Contributed – Kathryn Schaffer, School of the Art Institute of Chicago, 112 S. Michigan Ave., Chicago, IL 60603; kschaf2@saic.edu

Many experimental physicists use lab notebooks as a tool for scientific reasoning, and not always in ways that resemble the formal documentation and analysis emphasized in many lab classes. When designing an inquiry-based course on "Waves" for a non-science audience, I reflected on the role that narrative lab notebooks play in my own research as a tool for "figuring things out" through writing, sketching, and questioning. In the Waves course I am experimenting with anchoring student inquiry and class discussion in lab notebook work that is modeled on a similar approach. I will present the rubric I am currently using to assess student notebooks and discuss some of my successes and current challenges.

CG05: 5:40-5:50 p.m. Measuring Musical Consonance and Dissonance

Contributed – Michael C. LoPresto, Henry Ford Community College, Dearborn, MI 48128; lopresto@hfcc.edu

A brief overview of some research on quantifying the sensations of musical consonance and dissonance and comparing it to the judgment of humans subjects and a description of several classroom and laboratory activities on the subject based the research.

Session CH: Panel – Confessions of a First Year Faculty Member

Location: Tate Lab 170
Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Professional Concerns
Date: Monday, July 28
Time: 4–6 p.m.

Presider: Andrew Mason

Being a first-year physics faculty poses many challenges for which applicants are frequently not prepared when applying for a faculty position. We present a panel of recently hired junior faculty for discussion of this topic for the benefit of current graduate students, postdoctoral researchers, and early-career faculty. The panelists will discuss their respective hiring processes, as well as items they wished in retrospect they had been more informed on and/or better prepared. A diverse range of academic institutions and backgrounds are represented on the panel, with the intent to address a wide range of academic career plans. Faculty members who anticipate being involved in upcoming hiring searches are also encouraged to attend.

Panelists:

Jack Dostal, Wake Forest University
Danny Caballero, Michigan State University
Mary Bridget Kustusch, DePaul University
Brandon Lunk, Elon University

Session CI: Upper Division and Graduate Courses and Labs

Location: Tate Lab 131
Sponsor: AAPT
Date: Monday, July 28
Time: 4–5:40 p.m.

Presider: TBA

CI01: 4-4:10 p.m. Flipped Upper-Division Physics at the Colorado School of Mines

Contributed – Patrick B. Kohl, Colorado School of Mines, Golden, CO 80401; patkohlcsm@gmail.com

Eric S. Toberer, Colorado School of Mines

The flipped classroom is gaining popularity as a way of blending the best of online and in-person education, but efforts so far have been mostly (though not exclusively) focused on introductory classes. At CSM, we have developed and implemented two upper-division physics courses that use full or partial flips. Students are asked to watch one or more videos before class as preparation, with the actual class period occupied by Q&A, clicker questions, and various other activities. One of these two courses, PHGN 440, is a senior-level elective on solid-state physics. The other, PHGN 462, is a core course on electrodynamics. In this talk we'll report on methods, motivations, impressions, and early data, including but not limited to Youtube analytics, a qualitative survey, course evaluations, and a PER-based content inventory.

CI02: 4:10-4:20 p.m. Dynamics of Masses Subject to Counter Moving Flows

Contributed – Joseph O. West, Indiana State University, Department of Chemistry and Physics, Terre Haute, IN 47809; Joseph.West@indstate.edu

Maarij Syed ,Rose-Hulman Institute of Technology

The dynamics of objects accreting mass from a uniform background "mist" of small particles are a staple of the "changing mass" component of advanced undergraduate mechanics courses. Such courses typically enroll high ability sophomores and juniors, and challenge students' abilities to model continuous processes. A short review of known accretion models that are particularly useful as they permit analytic solutions is given. In addition, another class of object-mist interaction models involving the motion of symmetric objects (prism, disk, and sphere) in counter flowing mists is introduced. These allow analytic solution for inelastic, non-accreting inelastic, and elastic object-mist interactions. Relative velocity and "sound barrier" effects are investigated and connections to a similar relativistic system are emphasized. Students are challenged to build increasingly complex simulations suitable for numerical modeling. We hope to test this topic in the next iteration of an advanced mechanics courses with web-enabled content.

CI03: 4:20-4:30 p.m. Students' Approaches to Vector Calculus in Electrodynamics

Contributed – Paul van Kampen, CASTeL & School of Physical Sciences, Dublin City University, Collins Avenue Dublin, - 9 Ireland; Paul.van.Kampen@dcu.ie

Laurens Bollen, Mieke De Coc,k Department of Physics and Astronomy, KU Leuven, Belgium

Vector calculus plays an important role in post-introductory electromagnetism courses, but little research has been done on students' understanding of "divergence" and "curl" in an electrodynamics context. In this study we investigate second year students' conceptions of "divergence" and "curl". These students already completed an introductory electromagnetism course that leads up to Maxwell's equations in integral form plus at least two calculus courses including a chapter on vector calculus that focuses on proofs and evaluation. We report on the results from pre-tests and post-tests taken at the start and at the end of the 13-week semester. Both include open-ended questions that examine students' approaches to calculations, graphical interpretations and conceptual understanding. Analysis focuses on the solution methods and thinking processes rather than the answers. This work is the onset to a reformation of the tutorials in this matter.

CI04: 4:30-4:40 p.m. Teaching Quantum Mechanics, and Quantum Statistical Mechanics to Sophomores

Contributed – Deepthi Amarasuriya, Northwest College, Powell, WY 82435-1887; deepthi.amarasuriya@gmail.com

Most students are introduced to topics in quantum mechanics as sophomores, in Modern Physics. This material relies heavily on concepts and techniques covered in Differential Equations I, and Linear Algebra, which students may be taking concurrently, as well as on partial differential equations, special functions, and probability distributions, which are commonly taught at the junior level. I present some strategies I have successfully implemented in Modern Physics that help me teach the material effectively while helping students build the requisite mathematical foundation.

CI05: 4:40-4:50 p.m. Student Understanding of the Physics of Hydrology

Contributed – Jill A. Marshall, University of Texas at Austin, 1 University Station D5705, Austin, TX 78712-0382; marshall@austin.utexas.edu

Adam Castillo, Meinhard B Cardenas, University of Texas

For a full understanding physical hydrology, students must master conservation of mass, Newton's laws of motion, the second in particular, laws of thermodynamics (conservation of energy), and the relationship between flux, resistance, and gradient (analogous to Ohm's Law). Hydrology students do not always relate the specialized laws of hydrology to the fundamentals they learned in their physics class, and mathematical treatments do not always develop a conceptual understanding that promotes transfer. I will report on an extended study of student understanding in an upper division and graduate physical hydrology course, with and without the addition of COMSOL Multiphysics modeling activities in the curriculum. Student understanding was measured with a pre-/pos-t assessment and volunteer students were interviewed about their understanding in the course. This research was supported by a US National Science Foundation CAREER Grant (EAR-0955750).

CI06: 4:50-5 p.m. Creating Novel Microscopes in an Optics Course

Contributed – Dyan Jones, Mercyhurst University, Erie, PA 16505; djones3@mercyhurst.edu

Shauna Novobilsky, Rebecca Wheeling, Mercyhurst University

Over the past two years we have been developing a non-traditional upper division optics course. The course is non-traditional for two reasons. First, the primary constituents are not physics majors, but life science students. Second, it expands the concept of Studio optics to include project-based learning that focuses on the students' creation of novel microscopes. This talk will be a report on the first full implementation of the course and will highlight the optical systems the students created as well as their biological applications.

CI07: 5-5:10 p.m. Using an LED as a Single Photon Avalanche Diode

Contributed – Lowell McCann, University of Wisconsin - River Falls, 410 S. 3rd St., River Falls, WI 54022; lowell.mccann@uwrf.edu

The rising popularity of single photon experiments in undergraduate laboratories and Quantum Mechanics courses is giving more students an exposure to the detection methods and statistics involved in these types of investigations. However, the relatively high cost and high sensitivity of the Single Photon Avalanche Photodiodes (SPAD) used to detect the photons in these experiments can make faculty wary of letting students "play" with the detectors to investigate their behavior. In this talk, I will discuss the use of light emitting diodes (LED) as very inexpensive (and inefficient) SPADs that students can investigate without fear. The LED SPADs present a very rich parameter space for students to explore, and provide a wonderful application of their knowledge of electronics.

CI08: 5:10-5:20 p.m. An Advanced Laboratory in Alpha- and Beta Spectroscopy II*

Contributed – Frederick D. Becchetti, University of Michigan, Physics Department, Ann Arbor, MI 48109-1040; fdb@umich.edu

Ramon Torres-Isea, Michael Febbraro, Jay Riggins, University of Michigan

As part of a planned upgrade to our intermediate and advanced physics laboratory sequence, we have developed a low-cost, compact multi-functional apparatus for experiments in alpha- and beta-spectroscopy using multiple setups. As previously shown (Winter 2013 AAPT meeting, paper AB06) it has provisions for a novel ring-magnet that is utilized as a high-efficiency beta spectrometer to demonstrate relativistic effects for energetic beta particles. The same device, w/o magnet as we will show, can be used for experiments in alpha-particle spectroscopy and Rutherford scattering. In particular, the use of the moveable silicon detector can provide detailed data on the energy loss and straggling of alpha particles in matter and the resulting sharp Bragg curve at the end of the range. The latter e.g. is a key feature in the use of ion beams in radiation oncology to target and kill cancer tumors with minimal collateral radiation.

*Work supported in part by NSF Grant PHY 0969456 and NSF REU program.

CI09: 5:20-5:30 p.m. Angular Distribution of Na22 Decay Coincidence Measurements: Novel Results

Contributed – Thomas M. Huber, Gustavus Adolphus College, 800 West College Ave. St Peter, MN 56082; huber@gustavus.edu

Spencer Batalden, Ross Breckner, Gustavus Adolphus College

A common advanced laboratory experiment in nuclear physics involves using a pair of gamma detectors to measure the decay products from Na22. Because Na22 decays by positron emission, the decay signature involves a pair of back-to-back 511 keV gammas from the positron annihilation, along with a 1275 keV gamma. The energy and angular distribution of decay gammas can be determined using a NIM coincidence trigger circuit and multichannel analyzer monitoring a pair of NaI(Tl) detectors mounted to a goniometer table. We will describe how accidental pile-up in the detectors leads to somewhat unexpected artifacts in the measured angular distributions and energy spectra. We also will describe a simple geometric model that can be compared to the experimental angular distribution to determine the effective diameter of the NaI(Tl) detectors. These observations significantly enhance the pedagogical value of this traditional advanced laboratory experiment.

CI10: 5:30-5:40 p.m. It's (Not) Rocket Science: Undergraduate Goldstein

Contributed – Alan G. Grafe, University of Michigan-Flint, 303 E. Kearsley St., Flint, MI 48502-1950; grafe@umflint.edu

An error in the rocket problem (Chapter 1, Exercise 13) in the third edition of Goldstein's graduate Classical Mechanics text is used as a case study for the use of computational research tools such as Mathematica in undergraduate Classical Mechanics courses. We will see that this computational tool allows for a much deeper exploration of the physics of the situation in a manner that is accessible to undergraduate students.

Session CJ: Using Games to Teach Physics

Location: STSS 114
Sponsor: Committee on Physics in High Schools
Date: Monday, July 28
Time: 4–4:40 p.m.

Presider: Diane Riendeau

CJ01: 4-4:10 p.m. Review Games to Strengthen Skills and Add Fun

Contributed – Elisa Cardnell, Carnegie Vanguard High School, Houston, TX 77019; elisacardnell@gmail.com

Darilyn Krieger, Carnegie Vanguard High School

At the end of each unit, it is necessary to synthesize the material and apply it to problems. We discovered that a competition (even in which it was possible for all students to "win") was effective at engaging all students in putting together vocabulary, simple problem solving, units and theorems. However, some students are great at learning concepts, but struggle with applying the necessary equations to word problems. We developed a second review game that has students match multi-step physics problems with an assortment of equations in order to review the unit material and prepare for the unit exam.

CJ02: 4:10-4:20 p.m. Using "Power Grid" in a First Year Seminar

Contributed – Jack A. Dostal, Wake Forest University, Winston Salem, NC 27109; dostalja@wfu.edu

The strategy-based board game Power Grid demonstrates political, economic, and physical issues relevant to power generation and transmission. It is used in a First Year Seminar entitled Power and the U.S. Electrical Grid in which students learn about and discuss the interplay among these competing interests. The seminar is open to incoming freshmen of all backgrounds, but is commonly populated by prospective science and business/finance majors. The game opens up an avenue to discuss the physics behind power generation, energy density of natural resources, transmission wire power loss, and many other physics concepts. Gameplay mechanics and related activities will be presented.

CJ03: 4:20-4:30 p.m. Teaching Physics in a Tap-Happy World

Contributed – Matthew A. Blackman, The Universe and More, 37 Hill St., Morristown, NJ 07960; blackmanm@madisonpublicschools.org

Are your students tap-happy for Flappy Bird? Fear not! A new generation of educational physics games is engaging students like never before. I am a physics teacher and a game designer determined to disseminate a new breed of educational physics games. Because the majority of the games currently available on the market suffer from a lack of sound pedagogy and creativity, I decided to make my own to combat these mundane, glorified quiz type games, and make them available to the physics education community for free. My games have received an overwhelmingly positive response by thousands of teachers across the United States and 40 countries. Join me as I demonstrate how my games can be a versatile and effective teaching resource, proven to get your students to stop tapping and to start thinking. You'll learn how the games can be used for student collaboration, to flip your classroom and beyond!

CJ04: 4:30-4:40 p.m. Card Games to Teach Scientific Thinking

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

Leon Lederman, in his book *The God Particle*, uses a game as a metaphor for science: imagine aliens trying to deduce the rules for soccer, but through a quirk of alternate evolution, they cannot see the ball. Through observation and deduction, they work out what is going on. In this talk, I will describe two card games, known as Mao and Eleusis, that can be used to bring this metaphor to life in the classroom and make the process of scientific deduction tangible, in a controlled environment, to the students. In both games the goal of the game is to figure out the rules. Many aspects of scientific inquiry and discovery map directly to the process of playing these games. I have used a multi-step procedure to introduce the students to a game, deepen their engagement with it, and then debrief and show how in playing the game, they naturally fell into scientific thinking patterns -- patterns that can be extended to the laboratory and reinforced throughout the semester.

Session CK: Interactive Lecture Demonstrations – Whats New? ILDs Using Clickers and Video Analysis

Location: STSS 114
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Research in Physics Education
Date: Monday, July 28
Time: 4:50–6 p.m.

Presider: Priscilla Laws

CK01: 4:50-5:20 p.m. Interactive Lecture Demonstrations: Active Learning in Lecture Including Clickers and Video Analysis

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

Ronald K. Thornton, Tufts University

The results of physics education research and the availability of microcomputer-based tools have led to the development of the Activity Based Physics Suite.[1] Most of the Suite materials are designed for hands-on learning, for example student-oriented laboratory curricula such as RealTime Physics. One reason for the success of these materials is that they encourage students to take an active part in their learning. This interactive session will demonstrate "through active audience participation" Suite materials designed to promote active learning in lecture?—Interactive Lecture Demonstrations (ILDs),[2] including those using clickers and video analysis.

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).

CK02: 5:20-5:50 p.m. Interactive Lecture Demonstrations: Effectiveness in Teaching Concepts

Invited – Ronald Thornton, Tufts University, Medford, MA 02155-5555; ronald.thornton@tufts.edu

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).

CK03: 5:50-6 p.m. ILDs Using "Energy Skate Park" and "My Solar System" PhETs

Contributed – Rebecca Forrest, University of Houston, 617 Science & Research Bldg. 1, Houston, TX 77204-5005; rforrest@uh.edu

Interactive Lecture Demonstration (ILD) worksheets were created based on the "Energy Skate Park" and "My Solar System" PhET Interactive Simulations available at http://phet.colorado.edu. The worksheets are implemented following the Eight-Step ILD procedure, with PhET simulations used in place of physical demonstrations. This allows use of the ILD method in situations that cannot easily be tested with classroom demonstrations, such as with the universal law of gravity.

Session TOP06: Graduate Student Topical Discussion

Location: Tate Lab 166
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Graduate Education in Physics
Date: Monday, July 28
Time: 6–7 p.m.

Presider: Ben van Dusen

This session is the primary opportunity for members of the PER graduate students community to meet and discuss common issues.

Plenary: The Uncanny Physics of Superhero Comic Books

Location: Northrop Auditorium
Date: Monday, July 28
Time: 7:30–8:30 p.m.

Presider: Mary Mogge

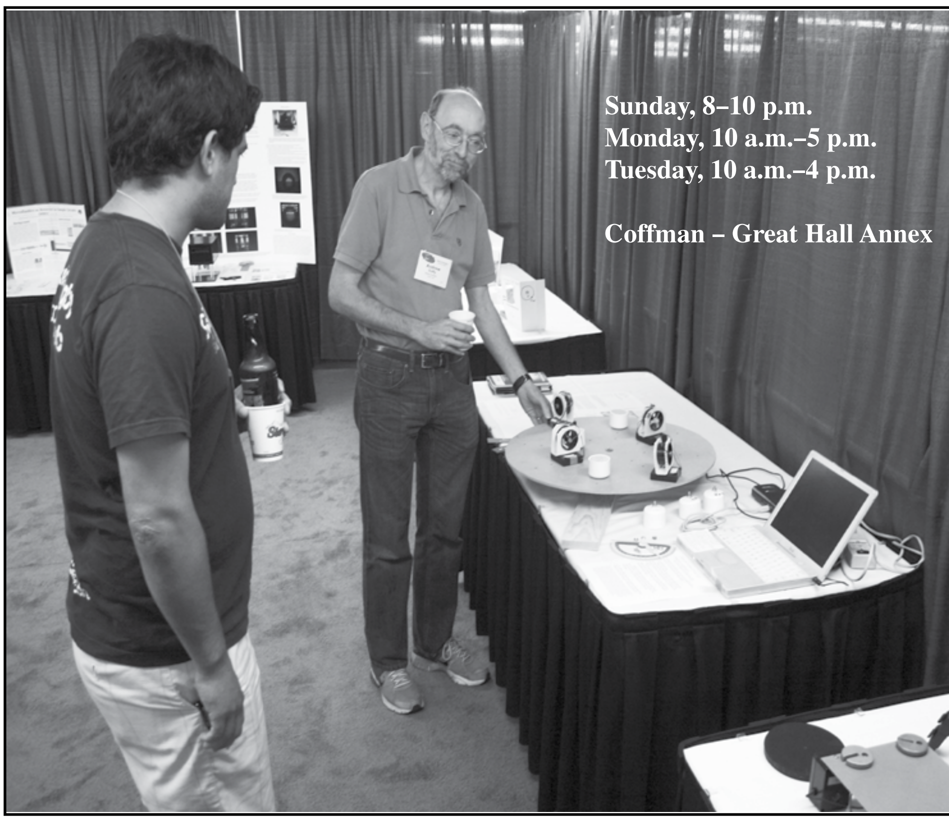
James Kakalios

James Kakalios, Taylor Distinguished Professor, University of Minnesota, School of Physics and Astronomy

In 2001 I created a Freshman Seminar class at the University of Minnesota entitled: "Everything I Know About Science I Learned from Reading Comic Books." This is a real physics class that covers topics from Isaac Newton to the transistor, but there's not an inclined plane or pulley in sight. Rather, ALL the examples come from superhero comic books, and as much as possible, those cases where the superheroes get their physics right!

This class drew a great deal of media attention in 2002 with the release of the first "Spider-Man" film, and led to my writing a popular science book *The Physics of Superheros*. My talk will show how superhero comic books can be used to illustrate fundamental physics principles. For example, was it "the fall" or "the webbing" that killed Gwen Stacy, Spider-Man's girlfriend in the classic "Amazing Spider-Man # 121"? How does Kitty Pryde from the "X-Men" comics and movies use quantum mechanics to walk through walls? Why does the Flash become heavier as he tries to run at the speed of light? All this, and the answers to such important real life questions as the chemical composition of Captain America's shield, and who is faster: Superman or the Flash? will be discussed. In my presentation I will describe the various ways that students' interest in these four-color adventurers can be leveraged to present real science in an accessible way. If superheroes can spark an interest in science in students and the general public—well, it wouldn't be the first time these heroes have saved the day!

Meet the author following plenary for a book signing!



Be sure to check out the Apparatus Competition entries in the PIRA Resource Room!

PST1: Poster Session 1

Location: Coffman Union ground floor
Date: Monday July 28
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 may be set up starting at 8 a.m. Monday and then should be taken down by 10 p.m. Monday)

A – Astronomy Posters

PST1A01: 8:30-9:15 p.m. Astronomy Demonstration Videos Focusing on Phase Changes

Poster – Kevin M. Lee, University of Nebraska, Lincoln, NE 68588-0299; klee6@unl.edu

Cliff Bettis, 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 focus on recently developed videos involving phase changes. Individual videos have emphasis on 1) the fact that phase depends upon temperature and pressure, 2) that liquids are rare in astronomy since they require the pressure of an atmosphere, 3) the sublimation of carbon dioxide and Martian polar caps, and 4) geysers of nitrogen snow on Triton. These materials are publicly available at http://astro.unl.edu and on YouTube and are funded by NSF grant #1245679.

B – Labs and Apparatus Posters

PST1B01: 8:30-9:15 p.m. A Not-So-Simple Pendulum Lab to Investigate Systematic Uncertainties

Poster – Farzan Beroz, Princeton University, Jadwin Hall, Princeton, NJ 08540; farzan@princeton.edu

Steven Jackson, Katerina Visnjic, Princeton

We present a case study on a novel ISLE-inspired mechanics lab implemented in a calculus-based introductory physics course at Princeton University. Students are instructed to perform a precision measurement (<1%) of gravitational acceleration using a 2 kg mass hanging from a 2 m wire. They know from class the simple model of a pendulum as a point mass on a massless string, and they can solve it analytically assuming the small angle approximation. In practice, the competing influences of the pendulum's non-idealized moment of inertia and corrections to the small-angle approximation give rise to systematic uncertainty in measurements and a discrepancy with the accepted value of g. After conducting the preliminary study, including identifying all relevant assumptions, students are guided to quantitatively account for these systematic uncertainties. Students gain a deeper understanding of how simplifying assumptions give rise to uncertainties, a crucial step in connecting experimental observations and theoretical predictions.

PST1B02: 9:15-10 p.m. Balloon-based Measurements of Cosmic Rays

Poster – Gordon C. McIntosh, University of Minnesota Morris, 600 E 4th St., Morris, MN 56267; mcintogc@morris.umn.edu

James Froberg, Stephen Sorenson, John Suihkonen University of Minnesota Morris

We have developed the capability of measuring the cosmic ray flux during balloon flights. Cosmic rays are high energy, ionized particles of interest in physics and astrophysics. Their flux varies with time, atmospheric depth, geomagnetic latitude, and the solar magnetic cycle. The measured flux depends on the area, direction, and solid angle of the detector. The measurement and analysis of cosmic ray fluxes have been incorporated in Modern Physics, Circuits and Electronic Devices, Experimental Physics, and in student research projects. The apparatus and interpretation of results will be presented.

PST1B03: 8:30-9:15 p.m. Cognitive Elements of a Hybrid Visual-tutorial Instruction Curriculum

Poster – Maria D. Gonzalez, Tecnologico de Juarez, Valle de Batopilas 11429 Ciudad, Juarez, NM 31310 Mexico; mdolores@nmsu.edu

Juan E. Chavez-Pierce Sergio M. Terrazas-Porras Jose V. Barron, Maria C. Salazar, University of Juarez

The University of Juarez and the University of Texas at El Paso have developed a hybrid instruction model to combine lab activities and a tutorial-based inquiry through the use of a video. We present the collection of cognitive elements that determines the micro-curriculum of this instructional model to understand the concept of electric charge. The elements are: 1) A conceptual pre-test: This test is administered to students previously to the projection of video, 2) A procedure-based video: Student can watch the video as many times they need during the development of lab, and 3) A conceptual post-test: Students take this test after lab. Both pre-test and post-test contain pairs of questions to explore possible students' transfer effects from mechanics to electricity concepts.

PST1B04: 9:15-10 p.m. Developing Writing Skills in the Introductory Laboratory*

Poster – Scott Bonham, Western Kentucky University, Bowling Green, KY 42101; Scott.Bonham@wku.edu

Kolton Jones, Western Kentucky University

Technical writing is a major learning outcome for our calculus-based physics laboratories. The recent renovation of the laboratories included developing an intentional strategy to help students learn technical writing skills. We combine several different approaches, which include providing students with detailed grading rubrics, having them grade example reports, and each week discussing and adding one more element of the report until they are writing complete reports. Data from surveys and assessment of student reports shows the instruction is an improvement over the previous approach to writing instruction, that different students find different elements of the instruction most helpful, and that different components of good technical writing develop at different rates over the course of the semester.

Sponsored in part by the National Science Foundation under grant DUE-0942293.

PST1B05: 8:30-9:15 p.m. Diffraction Experiments with Smartphone Displays

Poster – Craig C. Wiegert, University of Georgia, Deptartment of Physics and Astronomy, Athens, GA 30602-2451; wiegert@physast.uga.edu

Smartphone technology lends itself to an increasing variety of uses in the introductory physics instructional lab. Many physics experiments for smartphones rely on one or more of their many available sensors, such as the accelerometer, magnetometer, or GPS receiver. This poster presents an entirely different use of the smartphone in the lab: treating the high-density pixel display as a reflection diffraction grating. Students can easily use the resulting 2-D diffraction pattern to measure the pixel size to better than 1% accuracy.

PST1B06: 9:15-10 p.m. Effects of Concept-Based Experiments in Second Semester Introductory Physics Laboratories

Canceled

Poster – Larry J. Bortner, University of Cincinnati, Physics Department, Cincinnati, OH 45221-0011; bortnelj@ucmail.uc.edu

Kathy Koenig, Zachary Huard, Mahendra Thapa, University of Cincinnati

Many introductory physics students struggle with second semester topics that are further removed from the macroscopic observations and intuition more available in the mechanics and dynamics of the first semester studies. A move away from the traditional laboratory approach of verifying stated laws or relationships to one that develops the underlying concepts of electricity, circuits, magnetism, and optics shows promise in helping students perform better in lecture. The course structure involves pre-lab online quizzes over notes emphasizing concepts related to the experiment, group discussions, PhET simulations prior to actual measurements, checkpoints for instructors to determine group and individual progress during the lab, post-lab homework, and lab exams. Improvements between pre- and post-test scores using the Conceptual Survey of Electricity and Magnetism plus four additional problems on circuits from a Brief Electricity and Magnetism Assessment are reported and compared to results of traditional instruction.

PST1B07: 8:30-9:15 p.m. Independent Measurements of Q Factor of a Damped Oscillator

Poster – Steven R. Jackson, Princeton University, Jadwin Hall, Princeton, NJ 08540; srjackso@princeton.edu

Farzan Beroz, Katerina Visnjic, Princeton University

We present a novel mechanical oscillations lab developed for an introductory calculus-based physics course at Princeton University. The lab is an ISLE (Investigative Science Learning Environment) application experiment in which students are guided to design two independent experiments to measure the Q factor of a damped oscillator consisting of a mass attached to a spring and submerged in water. One method measures Q by driving the oscillator and comparing the low-frequency oscillation amplitude to that at resonance. Another measures Q from the amplitude decay rate of free oscillations. They consider assumptions made in the calculations for the two measurements, some of which are shared, and others that are not. Taking experimental uncertainties into account, they decide whether the measurements agree. If not, they identify which assumptions significantly affect their results and cause the discrepancy. In addition, students receive hands-on experience with the phase shift of a driven damped oscillator.

PST1B08: 9:15-10 p.m. Integrated Science Labs at Spelman College

Poster – Donald G. Franklin, Spelman College/Mercer University Hampton, GA 30228; dgfrank1@aol.com

Spelman College has been and continues to work on a unified approach to the science labs. The best examples are with Nerve cells. We go over cellular processes in physics labs and it comes out as series and parallel circuits. The chemistry and biology is the Sodium/Potassium Exchange. The Nerst equation is started in biology and finalized in physics. Our students see that a dialog exists between professors, and can respect physics in the process, rather than see it as a hurdle to jump on their way to graduation!

PST1B09: 8:30-9:15 p.m. MagLev Track Using off-the-Physics-shelf Lab Equipment*

Poster – Richard A. Zajac, Kansas State University - Salina, 2310 Centennial Road, Salina, KS 67401-8196; rzajac@sal.ksu.edu

Science Olympiad,[1] a national K-12 science competition, relies heavily on regional institutions to implement and administer dozens of individual competition events for area middle- and high schoolers. Limitations of time, resources, and personnel can require hosting institutions to creatively repurpose traditional lab equipment while conforming to national competition standards specified by unifying build descriptions, especially when specialty ordering is prohibitive. A quick and thrifty repurposing of the PASCO dynamics track (or equivalent) to fit the MagLev event specifications is presented as an example. The development of new setups for Science Olympiad events subsequently broadens the number of available applications of regular lab equipment within the undergraduate physics lab curriculum.

*MagLev cart by Merry Lewis and Colby Johnson, Salina South High School, Salina KS 67401.

1. www.soinc.org

PST1B10: 9:15-10 p.m. Experimenting with Musical Instruments

Poster – Michael C. LoPresto, Henry Ford Community College, Dearborn, MI 48128; lopresto@hfcc.edu

Examples of student laboratories on the physics of brass, woodwind, and string musical instruments based on research on the mechanisms by which the instruments produce musical pitches.

PST1B12: 9:15-10 p.m. Preparing Students for Research Experiences Through Instructional Labs in Electronics

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

Benjamin Pollard, Noah Finkelstein, University of Colorado

Electronic laboratory courses are a common component of many upper-division lab curricula, but are often not given adequate attention compared to the Advanced Lab. We began a project to develop goals, curricular materials and structure, and assessments to transform the junior-level course at the University of Colorado to prepare students to more easily transition into a research lab. A unique component of this work was to use interviews with a large number of graduate students working in experimental research labs to help develop content and skill goals for our electronics course.

PST1B13: 8:30-9:15 p.m. Squeezing Research into the Junior Physics Lab

Poster – Karen A. Williams, East Central University, 1020 E. 6th Ada, OK 74820 USA kwillims@mac.com

This poster is in response to the call for papers for "research-like experiences for all students." In my Junior Physics laboratory course I give the students an odd real-world problem to solve. It must be something 'off the wall' so that the solution can't be found on the Internet. They must design the research and work in groups where each group completes part of the work. Each week they meet to decide what work must be done next by the following group. I feel that this mimics real-world research in industry and forces teamwork and planning. After this project I have the students choose a project of their own to work on. They prepare a Powerpoint presentation of this research for their final exam. Often this research can be polished and expanded into a project that can be presented at student research symposiums. Student reaction to this new way of "doing lab" by doing research is positive. Many of our students are first-generation college students who know very little about research. They seem more at ease when it comes to applying for REU's after doing some research.

PST1B14: 9:15-10 p.m. Student-built Lab Equipment via an Arduino and Modeling Instruction

Poster – Nathan T. Moore, Winona State University, Winona, MN 55987-0838; nmoore@winona.edu

Andrew Haugen Winona State University

What would the introductory physics class be like, if, at the start of the term, every student bought an ultrasonic motion detector at the bookstore along with the latest edition of Serway? In the talk I'll describe how we've experimented with this idea by having our students purchase an Arduino-based "labkit" containing a microcontroller and a variety of cheap sensors. In two separate semesters we've had students create and deploy data acquisition systems with varying degrees of success. Given that many students don't arrive at the university with knowledge of programming, we've found that Modeling Instruction may provide a suitable intellectual framework for the inclusion of DIY lab apparatus. Briefly, students create models for how the sensors behave and report measurements, and then the students deploy these models to solve context-rich problems. The poster will present a lab using GPS antennae's in this DIY lab equipment context.

PST1B15: 8:30-9:15 p.m. The Magnetic Drive for a Foucault Pendulum Revisited

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

A Foucault pendulum is a popular and decorative item found in many science buildings around the country and the world. Typical specimens are long with a heavy bob and various ways to indicate its precession throughout the day. The fact that even a heavy pendulum will eventually stop is overcome by including a mechanical or magnetic drive of some form. Miami's Physics Department is moving into a new building later this year, and we will take our Foucault pendulum with us. We will use that opportunity to upgrade our magnetic drive system and also design a detector for indicating and recording the precession of the pendulum. This presentation shows different forms of drives that can be employed and discussed the advantages of each, as well as some problems that are encountered when working with Foucault pendula.

PST1B16: 9:15-10 p.m. The Magnetopause: Bringing Space Physics Into a Junior Lab*

Poster – Jim Crumley, College of St. Benedict / St. John's University, Collegeville, MN 56321-2000, jcrumley@csbsju.edu

Ari Palczewski, Stephen Kaster

Undergraduate students often have minimal exposure to many subfields of physics which are active areas of research. Space physics is an area that is particularly difficult to expose students to since it builds off of another area that most undergraduates see little of, plasma physics. The magnetopause is a convenient entry point into space physics, since it can be modeled as a pressure balance, which is a concept familiar from introductory physics. We use the Earth's magnetopause as the basis for a lab for junior physics majors. In the lab students analyze results from a NASA MHD simulation[1] and data from several spacecraft. In this lab, not only are students exposed to space physics, but they also develop their data analysis skills.

*This research was supported by an award from Research Corporation.

1. Simulation results have been provided by the Community Coordinated Modeling Center (http://ccmc.gsfc.nasa.gov) at Goddard Space Flight Center through their public Runs on Request system.

PST1B17: 8:30-9:15 p.m. Using Student's t-scores to Teach Measurement, Uncertainty, and Experimentation Skills

Poster – Natasha G. Holmes ,University of British Columbia, Vancouver, BC V6T 1Z1 Canada, nholmes@phas.ubc.ca

D. A. Bonn, University of British Columbia

Many introductory physics labs ask students to conduct experiments to see or experience physics concepts from class first hand. Students collect data from these experiments and are expected to analyze the data to make sense of the physics equations they've learned in class. In first year, however, many students have little to no experience with the probabilistic nature of data, measurement, and uncertainty and may also hold misconceptions about these ideas. Without that understanding, there are significant limitations to extracting physics concepts from the data and developing experimentation skills. In a first-year physics lab at UBC, we have removed the conceptual physics learning goals from the course and replaced them exclusively with goals for learning data analysis and measurement skills. This year in particular, we have introduced a tool analogous to the Student's t-test as a way to engage students in meaningful reflection of their data and to promote iterative experimentation. This poster will present some of these learning goals and associated teaching techniques, as well as evidence of its success.

PST1B18: 9:15-10 p.m. Vacuum Systems for Scientific Modeling

Poster – Tom M. Christensen, University of Colorado at Colorado Springs, 1420 Austin Bluffs Parkway, Colorado Springs, CO 80918; tchriste@uccs.edu

Marilyn Barger, Florida Advanced Technological Education Center

Raul Caretta, University of Minnesota

Richard Gilbert, University of South Florida

James Solomon, University of Dayton

Many high schools and universities have small vacuum systems that are used primarily for demonstrations. We review here more advanced laboratory applications of vacuum systems that have been developed as part of the annual AVS Science Educator's Workshop.* An emphasis on scientific modeling of exponential processes and non-ideal behavior of gasses can give students a better understanding of real science and engineering. We focus on two vacuum system experiments in which we connect theory, model, and observations. The first experiment examines the pump down characteristics of the vacuum system which is predicted to follow an exponential behavior. The second examines Boyle's law but demonstrates that the ideal gas model is not obeyed allowing discussion of a polytropic model and methods for determining the exponent in the model from experimental data. Additional advanced experiments will be summarized.

*https://www.avs.org/Education-Outreach/Science-Educators-Workshop

PST1B19: 8:30-9:15 p.m. Visualization of Vibrating Systems Using a Scanning Laser Doppler Vibrometer

Poster – Thomas M. Huber, Gustauvs Adolphus College, St Peter, MN 56082; huber@gustavus.edu

Peter Crady, Edward Kluender, Gustavus Adolphus College

A scanning laser vibrometer uses the Doppler shift of reflected light from an object to obtain incredibly precise visualizations of the deflection shape of vibrating objects. This system has been utilized to obtain insights about a wide variety of physical systems. We will describe measurements where the non-contact ultrasound radiation force excited vibrations of systems ranging from a microcantilever to the face of an acoustic guitar. Other measurements demonstrated that the reed in a reed organ pipe experiences accelerations in excess of 4000 g's. Visualization of the vibration of beakers excited by a speaker allowed better understanding of how they break. The vibrometer even enabled measurement of the sound waves traveling in tubes or emitted from ultrasonic ranger. Videos and curriculum guides have been produced to allow these visualizations to be utilized in classes. This project has been supported by NSF Grants: 0959858, 0900197, and 1300591.

PST1B20: 9:15-10 p.m. Musical Intervals and Scales

Poster – Michael C. LoPresto, Henry Ford Community College, Dearborn, MI 48128; lopresto@hfcc.edu

Classroom demonstrations and laboratory experiments on superposition of waves and Fourier analysis, and a student laboratory on analysis of the equal-tempered musical both scale, both based on research on the perception of musical intervals by the human ear.

PST1B21: 8:30-9:15 p.m. Physics Models & Experimental Errors

Poster – Daniel M. Crowe, Loudoun County Public Schools, Academy of Science, 21326 Augusta Dr., Sterling, VA 20164; dan.crowe@lcps.org

For the past several years, I have explicitly taught my students how to describe the physical and mathematical models used in textbook problems and the analysis of experiments. I have also explicitly taught my students how to use the physical models used to analyze experiments to identify sources of experimental error, especially systematic errors. I have also described to my students the relationship between physics models and the engineering concepts of tolerance and safety factor. I will describe specific examples of how these concepts have been used in my AP Physics C: Mechanics classes.

PST1B22: 9:15-10 p.m. Measuring Musical Consonance and Dissonance

Poster – Michael C. LoPresto, Henry Ford Community College, Dearborn, MI 48128; lopresto@hfcc.edu

An overview of methods of quantifying the sensations of musical consonance and dissonance compared to the judgment of human subjects and the application of this research in several classroom activities on the subject.

PST1B23: 8:30-9:15 p.m. More Than g, or No g

Poster – Glenda Denicolo, Suffolk County Community College, Port Jefferson Station, NY 11776; glenda.denicolo@gmail.com

We have carried out a study of the virtues and pitfalls of video analysis applied to two different experiments that measure acceleration: 1) falling at a faster rate than g (hinged board where free end accelerates faster than g when falling), and 2) falling with no acceleration (magnet rolling down a metal ramp with terminal velocity). Video analysis has been widely used in experiment-based project work in introductory mechanics, but it is not straightforward to perform precise measurements with this technique. We share our experiences in preparing, recording, and performing these video analyses. The chosen experiments are easy to perform in classroom and allow students to contrast their knowledge of free-fall motion with vertical motion at an acceleration greater than g, or no acceleration at all.

C – PER Posters

PST1C01: 8:30-9:15 p.m. A Good Diagram Is Valuable Despite Choice of Mathematical Approach to Problem Solving*

Poster – Alexandru Maries, University of Pittsburgh, 5813 Bartlett St., Pittsburgh, PA 15217; alm195@pitt.edu

Chandralekha Singh, University of Pittsburgh

Drawing appropriate diagrams is a useful problem solving heuristic that can transform a problem into a representation that is easier to exploit for solving the problem. A major focus while helping introductory physics students learn problem solving is to help them appreciate that drawing diagrams facilitates problem solution. We conducted an investigation in which 118 students in an algebra-based introductory physics course were subjected to two different interventions during the problem solving in recitation quizzes throughout the semester. Here, we discuss the problem solving performance of students in different intervention groups for two problems involving standing waves in tubes, one which was given in a quiz and the other in a midterm exam. These problems can be solved using two different methods, one involving a diagrammatic representation and the other involving mostly mathematical manipulation of equations. In the quiz, students were either (1) asked to solve the problem in which a partial diagram was provided or (2) explicitly asked to draw a diagram. A comparison group was not given any instruction regarding diagrams. Students in group (1), who were given the partial diagram, could not use that partial diagram by itself to solve the problem. The partial diagram was simply intended as a hint for students to complete the diagram and follow the diagrammatic approach. However, we find an opposite effect, namely, that students given this diagram were less likely to draw productive diagrams and performed worse than students in the other groups. Moreover, we find that students who drew a productive diagram performed better than those who did not draw a productive diagram even if they primarily used a mathematical approach. We also find that many introductory physics students in algebra-based courses struggle with relatively simple algebraic manipulations while solving physics problems but are capable of doing equivalent algebra when the manipulations are stand-alone tasks not tied to problem solving in physics.

*Work supported by the National Science Foundation

PST1C02: 9:15-10 p.m. Should Students be Provided Diagrams or Asked to Draw Them While Solving Introductory Physics Problems?

Poster – Alexandru Maries, University of Pittsburgh, 5813 Bartlett St., Pittsburgh, PA 15217; alm195@pitt.edu

Chandralekha Singh, University of Pittsburgh

Drawing appropriate diagrams is a useful problem0solving heuristic that can transform a given problem into a representation that is easier to exploit for solving it. A major focus while helping introductory physics students learn problem solving is to help them understand that drawing diagrams facilitates problem solution. We conducted an investigation in which 111 students in an algebra-based introductory physics course were subjected to two different interventions during recitation quizzes throughout the semester. They were either (1) asked to solve problems in which the diagrams were drawn for them or (2) explicitly told to draw a diagram. A comparison group was not given any instruction regarding diagrams. We developed a rubric to score the problem-solving performance of students in different intervention groups and found that students who were provided diagrams performed worse than the other students on two problems in electricity which involve considerations of initial and final conditions. We developed a hypothesis to explain why this counterintuitive result occurred and conducted interviews with fourteen students to evaluate this hypothesis. We found evidence which supports our hypothesis, which was that students provided with diagrams spent less time on the conceptual planning stage and sometimes jumped into the implementation stage without fully understanding the problem.

*Work supported by the National Science Foundation

PST1C03: 8:30-9:15 p.m. To Use or Not to Use Diagrams: The Effect of Drawing a Diagram in Solving Introductory Physics Problems

Poster – Alexandru Maries, University of Pittsburgh, 5813 Bartlett St., Pittsburgh, PA 15217; alm195@pitt.edu

Chandralekha Singh, University of Pittsburgh

Drawing appropriate diagrams is a useful problem solving heuristic that can transform a given problem into a representation that is easier to exploit for solving it. A major focus while helping introductory physics students learn problem solving is to help them appreciate that drawing diagrams facilitates problem solution. We conducted an investigation in which 111 students in an algebra-based introductory physics course were subjected to two different interventions during recitation quizzes throughout the semester. They were either (1) asked to solve problems in which the diagrams were drawn for them or (2) explicitly told to draw a diagram. A comparison group was not given any instruction regarding diagrams. We developed a rubric to score the problem-solving performance of students in different intervention groups. We investigated two problems involving electric field and electric force and found that students who drew productive diagrams were more successful problem solvers and that a higher level of relevant detail in a student's diagram corresponded to a better score. We also compared students' facility in calculating electric field vs. electric force and in calculating force on a point charge at a point efficiently from the electric field computed at the same point both immediately after instruction (quiz) and a few weeks after instruction (midterm). We found that the student performance on electric field remains stagnant while the performance on electric force improves significantly over time. Finally, think-aloud interviews were conducted with nine students who were at the time taking an equivalent introductory algebra-based physics course. These interviews supported some of the interpretations for the quantitative results, and were very useful in identifying some difficulties students still exhibited after having learned the concepts of electric field and electric force and after having been tested on it (in a midterm exam). The difficulties identified and instructional implications are discussed.

*Work supported by the National Science Foundation

PST1C04: 9:15-10 p.m. Student Difficulties in Translating Between Mathematical and Graphical Representations in Electrostatics: Impact of Increasing Levels of Scaffolding on Student Performance

Poster – Alexandru Maries, University of Pittsburgh, 5813 Bartlett, Pittsburgh, PA 15217; alm195@pitt.edu

Chandralekha Singh, University of Pittsburgh

Shih-Yin Lin Georgia, Institute of Technology

Prior research suggests that introductory physics students have difficulty with graphing and interpreting graphs. In this paper, we investigate introductory physics students' difficulties in translating between mathematical and graphical representations and the effect of increasing levels of scaffolding on students' performance. Ninety-five calculus-based introductory physics students were given a typical problem that can be solved using Gauss's law involving a spherically symmetric charge distribution (a conducting sphere concentric with a conducting spherical shell) in which they were asked to write a mathematical expression for the electric field in various regions and then graph the electric field. Previous preliminary research indicated that students have great difficulty in graphing the electric field as a function of the distance from the center of the sphere consistent with the mathematical expressions in various regions. Therefore, two scaffolding interventions with increasing levels of support were implemented in order to help them. Students who received the scaffolding support were either (1) asked to sketch the electric field in each region first (before having to plot it as a function of distance from the center of the sphere) or (2) asked to sketch the electric field in each region after explicitly evaluating the electric field at the beginning, mid and end points of each region. The comparison group was not given any scaffolding support and only asked to plot the electric field in all regions at the end of the problem. Analysis of student performance with different levels of scaffolding reveals that the appropriate level of scaffolding is not necessarily the one that involves more support (which is considered beneficial from an expert's perspective) and that the optimal level of support for a given student population can only be determined by research of the type discussed here. In particular, we found that more scaffolding may hinder students' performance and students may not even discern the relevance of the added support. We provide possible interpretations of these findings which were developed after in-depth interviews with some students.

PST1C05: 8:30-9:15 p.m. Influence of Visual Cueing on Eye Movements Using Think-Aloud Protocol

Poster – Elise Agra, Kansas State University, Department of Physics, Manhattan, KS 66506; esgagra@gmail.com

Xian Wu, John Hutson, Lester C. Loschky, N. Sanjay Rebello, Kansas State University

Research has shown that using visual cues to direct students' attention to relevant areas of a diagram can facilitate problem solving. In this study, we investigate the effect of visual cues on students' visual attention while they solve 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. Participants worked through four problem sets while their eye movements were recorded and they thought aloud about the problem solution. Each set contained an initial problem, six isomorphic training problems, and two transfer problems. Students in the cued condition saw visual cues overlaid on the training problems. We discuss the influence of both visual cueing and feedback on students' eye movements and think aloud data. This material is based upon work supported by the National Science Foundation under Grant Nos. 1138697 and 1348857.

PST1C06: 9:15-10 p.m. Metacognition and Epistemic Games in IPLS Problem Solving

Poster – Charles J. Bertram, University of Central Arkansas, Conway, AR 72035-0001; cabertram92@gmail.com

Andrew Mason, University of Central Arkansas

A metacognitive exercise in problem solving was given to an introductory physics for life sciences (IPLS) class over the course of the fall 2013 and spring 2014 semester. The exercise featured scaffolding in the form of a rubric students could use to note where they struggled in a group problem-solving effort. One of the concerns was that students who are not physics majors do not necessarily have the same epistemic framework as physics majors would for the classroom. As such, we examine written artifacts from the students' reflection activities for evidence of different epistemic games. We also describe a comparison of written artifacts to pre-post data from the FCI, MPEX, and CLASS surveys.

PST1C07: 8:30-9:15 p.m. Epistemic Impact on Metacognition in Cooperative Group Problem Solving

Poster – Andrew J. Mason, University of Central Arkansas, Conway, AR 72035-0001; ajmason@uca.edu

Charles Bertram, Cassandra Lange, University of Central Arkansas

Cognitive apprenticeship for physics problem solving has been demonstrated to show potential for students to reflect upon their problem-solving attempts. In the context of introductory physics for life sciences (IPLS), a concern exists that non-physics science majors may have attitudes towards physics that mitigate the efficacy of a metacognitive problem-solving exercise. A weekly metacognitive intervention was administered in a lab group problem solving setting for a first semester algebra-based introductory physics course. MPEX and CLASS surveys were used in a pre-post format for respectively the fall 2013 and spring 2014 semesters. Other forms of data include written artifacts from the students themselves about aspects of problem solving with which they struggled, as well as an end-of-semester survey about the usefulness of the exercise. We discuss the effectiveness of the reflection task with respect to the students? attitudes towards problem solving.

PST1C08: 9:15-10 p.m. Student Srategies Solving Graphically Based Physics Problems Invoking the Fundamental Theorem of Calculus

Poster – Rabindra R. Bajracharya. University of Maine. Orono, ME 04469; ab_study@yahoo.com

John R. Thompson, University of Maine

We have been investigating student understanding and application of the Fundamental Theorem of Calculus (FTC) in different physics contexts involving definite integrals. We conducted 14 semi-structured individual interviews with introductory physics students. Our analysis, using grounded theory, elicited various strategies to solve graphically based FTC problems. While many students struggled initially, at some point during the interviews students displayed the relevant and requisite mathematical knowledge, suggesting that they failed to access and/or apply the knowledge in the given physics contexts. Similar to prior studies on students dealing with mathematically based physics problems, we found the analysis perspectives of epistemological framing and epistemic games productive in interpreting some of the choices of strategies, the strategies themselves, and some individual steps observed. The framing perspective helps explain students' strategy-switching based on representations available or context familiarity. We discuss our findings and relate our results to those in the literature.

PST1C09: 8:30-9:15 p.m. Eye-Gazing Behavior of Students Solving Graphically Based Physics Problems

Poster – Rabindra R. Bajracharya, University of Maine, Orono, ME 04469; ab_study@yahoo.com

Jennifer L. Docktor, University of Wisconsin-La Crosse

John R. Thompson, University of Maine

We report on one aspect of our multi-mode study—using written surveys, interviews, and eye tracking—of student problem-solving of graphically based Fundamental Theorem of Calculus problems in mathematics and physics contexts. A free-head eye-tracking instrument recorded visual attention in the form of direction and duration of eye gaze in real time. We focused particularly on the proportion of time spent on various stimulus domains—lexicons, equations & symbols, graphs, and distractors. We also separately analyzed the proportion of time spent by participants on various features of the graphs. Our initial analysis of the direction and duration of participants' eye gaze indicate more time spent on equations and symbols than on other domains. We also found that participants who gave incorrect responses spent more time attending to irrelevant graphical features. We will present a summary of these findings and compare eye-tracking results to responses from interviews and written surveys.

PST1C10: 9:15-10 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

Alex Maries, Chandralekha Singh, University of Pittsburgh

Edit Yerushalmi, Weizmann Institute

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.

PST1C11: 8:30-9:15 p.m. What Resources Do Physics Experts Use When Solving Novel Problems?

Poster – Darrick C. Jones, Rutgers, The State University of New Jersey, Piscataway, NJ 08854-8019; dcjones@physics.rutgers.edu

AJ Richards, Eugenia Etkina, Rutgers, The State University of New Jersey

Gorazd Planinsic, University of Ljubljana

A central goal of physics education is to help students learn to think like a physicist when solving problems. But what exactly does it mean to think like a physicist? What do physicists do that allows them to successfully solve and understand complex, novel physics problems? We will present how we have searched for an answer to this question by using the resources framework to analyze videotaped records of physics experts solving novel problems. By focusing on moments when physics experts reasoned towards a deeper understanding of the problem and dissecting their discourse during these moments, we identify resources that physics experts activate as they make progress through the problem solving process. We search for patterns to identify resources with epistemological underpinnings which help experts make progress towards understanding a novel phenomenon. We discuss how frequently various resources are used and the implications these findings have on physics instruction.

PST1C12: 9:15-10 p.m. How Students Use Visual Representations When Solving Charge Distribution Problems

Poster – Alanna Pawlak, Michigan State University, Biomedical and Physical Sciences, East Lansing, MI 48824-1046; pawlakal@msu.edu

Leanne Doughty, Marcos Caballero, Michigan State University

In physics, we create simplified models of physical systems, which can be presented visually through the use of representations. Often, multiple representations are available to illustrate different aspects of the same model. For example, the area surrounding a charge distribution could be visualized as being filled with electric field vectors, electric field lines, or equipotential lines. While each representation appears different superficially, it is important that students recognize that each illustrates the same model. Additionally, students should be able to determine when a particular representation may be most productive, depending on the aspect of the model they wish to study. We observed students in small groups completing an activity requiring them to choose one of the previously mentioned representations in order to answer questions about charge distributions and justify their choice. We present results from analysis of a small number of videos and the emerging strategy for future investigations.

PST1C13: 8:30-9:15 p.m. Teaching Fluids to IPLS Students via Microscopic Representations

Poster – Daniel E. Young, University of New Hampshire, Durham, NH 03820; deq27@unh.edu

Dawn C. Meredith, University of New Hampshire

For introductory life science students, fluid dynamics is a topic that is important, relevant to biology, and yet difficult to understand conceptually. Our study focuses on probing understanding of pressure differentials, vacuums, and Bernoulli's equation which underpin ideas of fluid flow. Data was collected from written assessments and laboratory exercises in addition to teaching interviews, and was analyzed using the frameworks of resource theory and mechanistic reasoning to look for productive student ideas such as a microscopic viewpoint and gradient driven flow. We investigated whether a multiple-scale view of matter is useful for students when constructing models of pressure and fluid flow and will present both our model and a qualitative analysis of student work.

PST1C14: 9:15-10 p.m. Investigating Student Difficulties in Upper-Division Electromagnetism

Poster – Charles Baily, University of St. Andrews, School of Physics and Astronomy, St, Andrews, Fife, KY16 9SS UK; crb6@st-andrews.ac.uk

Cecilia Astolfi, University of St. Andrews

Qing Ryan, Steven Pollock, University of Colorado

Expanding our knowledge of student difficulties in advanced undergraduate physics courses is essential if we are to develop effective instructional materials. This poster focuses specifically on student difficulties in upper-division electromagnetism. We present quantitative data based on responses from students at multiple institutions to a research-based conceptual assessment developed at the University of Colorado Boulder (the Colorado UppeR-division ElectrodyNamics Test, or CURrENT). We also present qualitative results from interviews with individual students, and observations of student difficulties during lectures and optional homework help sessions. Common difficulties include, but are not limited to, relating the vectors appearing in Maxwell's equations in integral form to specific geometries; understanding the fields associated with an infinite solenoid; and interpreting diagrams and notation for reflection and transmission problems.

PST1C15: 8:30-9:15 p.m. Introductory Physics Students: Understanding of Electric Potential in DC Circuits

Poster – Ane Leniz, Donostia Physics Education Research Group, University of the Basque Country, EHU-UPV Plaza Europa 1 Donostia-San Sebastian, 20018 Basque Country, Spain; ane.leniz@ehu.es

Kristina Zuza, Jenaro Guisasola, Donostia PER Group

Electricity is an area of physics that students find significantly difficult to understand. In many introductory physics courses on electricity, the core of the theory of electric circuits is a set of simple DC circuit laws, which relate algebraically voltages, currents, and resistance. These laws are usually related to the Drude model of electric current. Previous research shows that relations between electrostatics and electrodynamics are still a source of teaching-learning problems in the first years of university. Research shows that students do not relate concepts studied in electrostatics with the phenomena that occur in electric circuits. This study investigates how students from two different universities and countries understand the relation between potential difference and current in a context close to DC circuits. The results show evidence that in current transitional situations students don't usually use potential difference to perform the analysis. They show deficiencies in the explanatory model of charge movement.

PST1C16: 9:15-10 p.m. Student Learning of Critical Circuits Concepts in Physics and Engineering*

Poster – Kevin Van De Bogart, University of Maine, Orono, ME 04469; kevin.vandebogart@maine.edu

MacKenzie Stetzer, University of Maine

As part of a new effort 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 circuits and electronics. Due to the considerable overlap in the content coverage, we have been able to administer the same (or similar) questions to students in both disciplines. A major goal of this work is to investigate the impact of disciplinary context on the nature of student understanding, including the prevalence of specific difficulties. This talk will focus on foundational concepts (e.g., loading) that are critical to the design and analysis of circuits in all courses studied. 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-1323426 and DUE-0962805.

PST1C17: 8:30-9:15 p.m. Assessing Gender Differences in Students' Understanding of Magnetism

Poster – Chandralekha Singh, University of Pittsburgh, Pittsburgh, PA 15260; clsingh@pitt.edu

Jing Li, 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. These trends persisted regardslesss of the instructors. We discuss possible reasons for these differences. We thank the National Science Foundation for support.

PST1C18: 9:15-10 p.m. Investigating Student Difficulties with Dirac Notation

Poster – Emily M. Marshman, University of Pittsburgh, Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, 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.

PST1C19: 8:30-9:15 p.m. Investigating Student Difficulties with Time Dependence of Expectation Values in Quantum Mechanics

Poster – Emily M. Marshman, University of Pittsburgh, Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, 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.

PST1C20: 9:15-10 p.m. Analogous Patterns of Student Reasoning Difficulties in Introductory Physics and Upper-Level Quantum Mechanics

Poster – Emily M. Marshman, University of Pittsburgh, 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.

PST1C21: 8:30-9:15 p.m. Assumptions and Idealizations in Students' Reasoning During Laboratory Activities

Poster – Benjamin M. Zwickl, Rochester Institute of Technology, Rochester, NY 14623-5603; benjamin.m.zwickl@rit.edu

Dehui Hu, Rochester Institute of Technology

Noah Finkelstein, H. J. Lewandowski. University of Colorado Boulder

Assumptions and idealizations play a significant role in developing and applying models to real-world situations. Assumptions make models more tractable, but also impact the design of experiments (through the introduction of possible sources of systematic error) and limit the range of validity of predictions. In this investigation, students conducted a think-aloud laboratory activity using LEDs. Videos were coded and analyzed using a framework developed for model-based reasoning designed for upper-division physics laboratory classes. The analysis focuses on multiple roles of assumptions within the activity: making, recognizing, and justifying assumptions; linking assumptions to limitations of the validity of theoretical predictions and measured results; and using knowledge of assumptions to iteratively improve experimental results.

PST1C22: 9:15-10 p.m. Spanning Student Reasoning about P-V Diagrams in Physics and Engineering*

Poster – Jessica W. Clark, University of Maine, Orono, ME 04468; jessica.w.clark@maine.edu

John R. Thompson, Donald B. Mountcastle

As part of a new effort to investigate the learning and teaching of concepts in thermodynamics and electronics in both physics and engineering, we have been examining student learning of thermodynamics in mechanical and chemical engineering and physics courses. In thermodynamics, students must grapple with multivariable dependence between state properties. They are also taught to use simplified models of real substances (e.g., ideal gas). By varying a task we have previously studied which probes students' understanding of the First Law, its constituent elements, and graphical representations, we access additional specific knowledge of the univariant temperature dependence of the internal energy of an ideal gas. Our results show that use of this concept varies across disciplines despite being covered in all. Additionally, the task alteration suppresses the most common previously identified difficulty and elicits others to give a more complete understanding of student reasoning.

*The work described has been supported in part by the National Science Foundation under Grant Nos. DUE-0817282 and DUE-1323426.

PST1C23: 8:30-9:15 p.m. Exploring a Logical Approach to Promoting Conceptual Understanding

Poster – David Maloney, Indiana University Purdue University, Fort Wayne, IN 46805; maloney@ipfw.edu

An important aspect of scientific understanding is the use of sequential, inferential reasoning. One school of psychology argues that humans reason through models. This project is exploring the presentation and use of explicit models of conditional and bi-conditional statements as a mechanism for promoting conceptual understanding. Students in a calculus-based introductory physics course were given a conditional and a bi-conditional statement involving everyday content. The truth status of each of the seven possible rearrangements of the original statements was identified for each case. Students then had a weekly homework assignment that required explicit use of these models. In addition, there was a test item of the same format on each of the four tests during the semester. This presentation will present the struggles the students had with using the logic involved, with the physics concepts and with connecting the physics with the logical reasoning.

PST1C24: 9:15-10 p.m. Causal Effects of Reasoning Skills and Epistemologies on Content Learning

Poster – Lin Ding, The Ohio State University, Department of Teaching and Learning, Columbus, OH 43210; ding.65@osu.edu

Multiple factors can affect content learning. Research in physics education has tapped into some key factors that are postulated to be causal agents of learning gains. These include student pre-instructional levels of scientific reasoning and epistemological sophistication. Previous work in this matter has largely relied on qualitative case studies or correlation analysis to demonstrate, separately, the positive relation of reasoning and epistemology with content learning. However, the postulated causality has not been explicitly verified through larger-scale integrative investigations. In this study, we use path analysis to test the causal influence of scientific reasoning and epistemology on content learning. Results show that student pre-instructional reasoning skills (measured by the Classroom Test of Scientific Reasoning) and epistemologies (measured by the Colorado Learning Attitudes about Science Survey) are significant causal factors for learning gains on the Force Concept Inventory. However, post-instructional epistemology is not a significant contributor to learning gains.

PST1C25: 8:30-9:15 p.m. Identifying Blended Ontologies for Energy

Poster – Benjamin W. Dreyfus, University of Maryland, Department of Physics, College Park, MD 20742; dreyfus@umd.edu

Ayush Gupta, Edward F. Redish, University of Maryland

Energy is an abstract concept, but students and experts alike reason about energy using ontological metaphors: metaphors that indicate what kind of a thing energy is. These metaphors include energy as a substance ("This object has a lot of energy") and energy as a vertical location ("It dropped down to a lower energy"). Both of these metaphors can be productive, but each one has its limitations. In our previous work, we have shown that students and experts can productively combine the substance and location metaphors for energy and coordinate them coherently. Here, we examine instances in which students are using both metaphors, and argue that, in some cases, students blend these two separate metaphors into a single ontology for energy. To determine this, we employ an integrated methodology, analyzing both the verbal metaphors and the gestures that the students use.

PST1C26: 9:15-10 p.m. It's "Just Math": A New Epistemic Frame

Poster – Steven F. Wolf, CREATE for STEM Institute, Michigan State University, East Lansing, MI 48824; wolfste4@msu.edu

Ying Chen, Paul W. Irving, Eleanor Sayre, Kansas State University

Marcos D. Caballero, Michigan State University

Physicists use mathematics as a tool to model physical phenomena. Students learn to use sophisticated mathematical tools (e.g, vector calculus and Taylor series) in their physics courses, but often struggle to employ them in novel situations. As part of a new collaboration between the Physics Education Research groups at Michigan State University and Kansas State University, we reviewed video of students solving a variety of physics problems in interview and small group settings. We identified patterns of student behavior and discourse that we are calling the "Just Math" epistemic frame. A specific epistemic frame can be described as the network of activations and inhibitions of resources in response to a person's current activity. The Just Math frame is marked by little or no verbal communication as well as a change in body language; transitions into and out of this frame are both obvious and abrupt. Furthermore, these transitions appear universal, inevitable, and predictable.

PST1C27: 8:30-9:15 p.m. Differences of Elementary School Students' Learning Process in "Velocity of the Object" According to their Mathematical Ability

Poster – Kyungmi Lee, Seoul National University of Education, Seochogu Seochojungangro 96 Seoul, GyeongGi-Do 137-875; kyungmilee1004@hanmail.net

Many elementary school students have difficulties in learning "velocity of the object." We have approached to this problem with a question of a relationship between mathematical ability and learning process of this subject. We assessed the mathematical ability of students as well as the achievement of the students in the subject. Based on the two results, we separated the students into three groups; high, middle, and low. We also acquired the correlation data between mathematical ability and achievement of the subject - velocity of the object. And then we interviewed the students in each group to ask their learning process. As a consequence of this research, we found out some meaningful suggestion for teaching and learning this subject. We'd like to share our findings.

PST1C28: 9:15-10 p.m. Becoming a Physicist: The Roles of Research, Mindsets, and Milestones

Poster – Paul W. Irving, Kansas State University, 116 Cardwell Hall, KSU Manhattan, KS 66506; paul.w.irving@gmail.com

Eleanor C. Sayre, Kansas State University

The development of an appropriate subject-specific identity is a strong influence on retention within a discipline. In physics, there is a strong link between how students identify with being a physicist and whether or not they have decided on a physical science career. As part of a longitudinal study into subject-specific identity development in upper-level physics students, we examined students perceptions on various aspects of their physics identity. Using a phenomenographic methodology, we present four different perceptions of what it means to be a physicist. The categories of perception centered around the level of exclusivity students associate with being a physicist and the importance they placed on the relationship between being a physicist and conducting physics research. A subset of the original students were reinterviewed to determine if their perceptions of being physicists had changed. Similar categories emerged but there were significant changes in individual students' perceptions.

PST1C29: 8:30-9:15 p.m. Supporting Physics Majors: More than Instruction

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

Michael E. Loverude, California State University Fullerton

As instructors, our primary goal is to help students learn physics. We naturally focus our efforts on preparing course materials and managing classroom interactions. In this poster, we argue that awareness of, understanding of, and participation in the students' experiences outside of the classroom can not only enhance learning in the classroom but also support student persistence and enthusiasm for physics. We present case studies of physics majors constructed using data from reflective journals, classroom observations and individual interviews. Some of the experiences described as pivotal by the students were not completely academic in nature and thus were easily overlooked or ignored by instructors. We will highlight the impact that these experiences have had on the students' progress through their majors. Further we suggest that while instructors are understandably reluctant to delve too deeply into students' personal lives, there can be considerable benefits in the students' development.

PST1C30: 9:15-10 p.m. Beyond the Numbers: Finding Mechanisms to Support Diversity

Poster – Vashti A. Sawtelle, University of Maryland, College Park, MD 20742-2421; vashti.sawtelle@gmail.com

Julia Svoboda Gouvea, University of California, Davis

Chandra Turpen, University of Maryland, College Park

Understanding issues of diversity and equity in physics has historically taken the lens of documenting broad patterns of participation of women and ethnically underrepresented groups. This work has explored reasons for differing levels in participation including conceptual understanding, physics identity, and student self-efficacy. A common aim of this work has been to examine the impact of these variables on the prevalence of underrepresented groups in physics. We present an alternative lens on diversity and equity that centers on better understanding and supporting student trajectories of participation over time. Drawing from case study data of a biology major in an introductory physics class, we argue that access to a professional community of scientists must start from exposure to, participation in, and developing an affinity towards a variety of scientific practices. We articulate how this perspective informs a model of supporting diverse students who are commonly disenfranchised from physics.

PST1C31: 8:30-9:15 p.m. Vector Addition in Different Contexts: A Fine-Grained Study

Poster – Philip B. Southey, University of Cape Town, 10 Zion Road, Claremont Cape Town, 7700 South Africa; philsouthey@gmail.com

Saalih Allie, University of Cape Town

The acquisition metaphor of learning is often used by teachers of physics: Students acquire a particular concept, and then transfer this concept to new contexts. In particular, one might say students acquire the mathematical concept of "vector addition" and apply it in (transfer it to) numerous physical contexts. In this study, 200 freshmen taking an introductory physics course were asked to calculate the total force, total displacement and total momentum in simple contexts involving vector addition at right angles. Another similar group of 200 students were asked to calculate the net force, net displacement, and net momentum. The students did significantly worse when adding momenta, and they did significantly better when asked to calculate the "net" quantity (rather than the "total" quantity). These results are inconsistent with a basic "acquisition-transfer" perspective of learning. A fine-grained analysis of subsequent interviews and questionnaires was also conducted.

PST1C32: 9:15-10 p.m. Explanatory Coherence in an Introductory Physics for Life Scientists Course

Poster – Benjamin D. Geller, University of Maryland, College Park, Department of Physics, College Park, MD 20742; geller@umd.edu

Benjamin W. Dreyfus, Julia S. Gouvea, Vashti Sawtelle, Chandra Turpen, University of Maryland, College Park

Life science students crave coherence among the science courses that they are required to take, and are frustrated when these courses fail to talk to each other in meaningful ways. In an effort to bridge disciplinary divides, we have iteratively designed and implemented an Introductory Physics for Life Scientists (IPLS) course that aims to unpack the physical mechanisms underlying a number of authentic biological phenomena. We draw on case-study data to examine what it looks like for students in our course to make connections between fundamental physical principles and meaningful biological questions. In particular, we explore the multiple ways in which an explanation can be "mechanistic" in the context of interdisciplinary sense making, and the affective markers that indicate satisfactory explanation. We argue that achieving explanatory coherence in an IPLS course demands that we take up authentic biological phenomena for which highly detailed accounts are not practical.

PST1C33: 8:30-9:15 p.m. Correlations Between Math Background and Class Performance in Conceptual Physics

Poster – Lynne M. Raschke, The College of St. Scholastica, 1200 Kenwood Ave., Duluth, MN 55811; lraschke@css.edu

Katheryne Anderson, The College of St. Scholastica

The College of St. Scholastica teaches a one-semester conceptual physics class for students from a variety of majors, including pre-service teachers, students intending to become occupational therapists, and students fulfilling a natural sciences general education requirement. There was no math pre-requisite for the class, but the class utilized math at the level of introductory middle-to-high school algebra. We investigated whether there was a correlation between students' math backgrounds and their performance in the class. Student performance was assessed in three areas: conceptual questions, questions that required applying physics knowledge, and quantitative questions. Four years of data showed that, even controlling for student GPAs, students with less math preparation performed worse not only in the quantitative aspects of the course, but also in the conceptual and applied questions. This raises the question of why we see this disparity and how we can better support student learning in this type of class.

PST1C35: 8:30-9:15 p.m. Successes and Challenges in Scaling-up NEXUS/Physics Labs

Poster – Kimberly A. Moore, University of Maryland, College Park, MD 20742; MoorePhysics@gmail.com

Wolfgang Losert, John Giannini, University of Maryland, College Park

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 2013-2014. These labs address physical issues at biological scales using microscopy, image and video analysis, electrophoresis, and spectroscopy in an open, non-protocol-driven environment. We have collected a wealth of data (surveys, video analysis, etc.) that enables us to get a sense of the students' responses to this curriculum in a large-enrollment environment and with teaching assistants "new" to the labs. In this poster, we will provide a broad overview of what we have learned and a comparison of our large-enrollment results to the results from our pilot study. Special emphasis will be placed on successes and challenges accompanying this scaling-up. (This work is supported by funding from HHMI and the NSF.)

PST1C36: 9:15-10 p.m. The CU Science Education Initiative: Examining the Model and its Impact

Poster – Stephanie Chasteen, University of Colorado Boulder, UCB 390, Boulder, CO 80309; stephanie.chasteen@colorado.edu

Katherine K. Perkins, University of Colorado Boulder

In 2005, the Science Education Initiative (SEI) at the University of Colorado was launched as a $5 million, university-funded project to support departments in improving science education (http://www.colorado.edu/sei). The SEI funded work across seven STEM departments to transform dozens of courses using a scientific approach to educational reform driven by three questions: What should students learn? What are students learning? Which instructional approaches improve student learning? The SEI is structured with a small team of central staff, and a cohort of Science Teaching Fellows -- postdocs, hired into individual departments, who partner with faculty to identify learning goals, develop instructional materials, and research student learning. Key elements of the program are its departmental focus and bottom-up structure. As the SEI draws to a close, we have an opportunity to reflect upon the impacts of the program. This poster will use multiple data sources to examine and highlight the outcomes of the SEI model, including both the affordances and lessons learned.

PST1C37: 8:30-9:15 p.m. "Chaos Is Cool": Teacher Perceptions of Physics and Engineering Integration

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

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

As teachers prepare to bring engineering into K-12 science classrooms, guided by the calls of national reform documents (National Research Council, 2013), there is an importance to not only understand how teachers are accomplishing this, but to also understand their experiences and perceptions of the nature of engineering integration. By examining classroom practices and understanding teachers' experiences in integrating engineering into their instruction, we can better learn how to prepare these teachers. This study investigated the classroom practices of high school physical science teachers following an intensive professional development on engineering integration. Our findings suggest that teachers often drop explicit physics connections in these integrated lessons in favor of maintaining student interest and engagement with hands-on engineering activities. This student interest and engagement may be linked to teachers' willingness to bring engineering to their classrooms and has the potential to increase student learning of physics concepts.

PST1C38: 9:15-10 p.m. STEM in United States and STEM in Korea

Poster – Hyunjung Kang, 104-401, Ssangyong Sweet .(dot) Dongjak-gu, Seoul, N/A 156-726, Rep. of KOREA; bkshj01@sen.go.kr

I have compared the STEAM education in Korea to the STEM education in the United States with reference to various documents. "A" in STEAM stands for Arts. I have attempted to make a comparison between the emphasis placed within the field of science education and the spread of the new wave in science education. In Korea, they intend to fuse arts with science in order to promote the students' self confidence and interest in learning science, while placing emphasis on both quality and quantity of learning science in relation to mathematics and engineering design for understanding real life. Also, the creation of the STEAM education has been headed by an organization that is funded by the government. They have developed a large amount of class materials, have trained many teachers, and have supported the schools that the STEAM is introduced to. They have also pushed schools and teachers in various ways like boot camp. I have examined the process of spreading STEAM and have compared that of STEM in the United States.

D – Other Posters

PST1D01: 8:30-9:15 p.m. Getting Involved with AP: Information for H.S. and College Faculty

Poster – Dedra N. Demaree, Georgetown University, 1646 21st St N, Apt 1, Arlington, VA 22209; dd817@georgetown.edu

Advanced Placement® Physics 1, 2, and C are designed to provide rigorous college-level content to high school students. Ongoing collaboration between college and high school faculty, facilitated by the College Board, is instrumental to the success and integrity of the AP Program. Participation can be through course and assessment design, exam development, scoring and analysis, and delivery of high-quality professional development. This shift from Physics B to Physics 1,2 is an exciting time to be involved with the AP program. Each learning objective combines specific physics content knowledge with one of seven foundational science practices, and students will engage in hands-on explorations of physics and inquiry labs. Being part of the development process for the courses provides a rare opportunity to have a national-level impact on physics education. This poster presents an overview of the various roles that high school and college faculty can play in this important program.

PST1D03: 8:30-9:15 p.m. Student-created Problem Scenarios in Introductory Physics for Life Science

Poster – Nancy Beverly, Mercy College, Dobbs Ferry, NY 10522; nbeverly@mercy.edu

The increased availability of information online allows students to find enough data to apply mathematical models to real-life scenarios of their own choosing. This is especially important for life science students as it enables them to make their own meaningful connections of physics to life science phenomena and gives them more relevant problem solving practice. Typical end-of-chapter problems ask students to find an unknown based on given information and assumed use of a mathematical model covered in the chapter. In this alternative approach, students raise their own questions and determine what information they need to find to calculate an answer, using a particular model. Examples, successes, and pitfalls will be presented.

PST1D04: 9:15-10 p.m. Integrating Physics Concepts in an Anatomy and Physiology Learning Activity

Poster – Bijaya Aryal, University of Minnesota-Rochester, 300 University Square, Rochester, MN 55904; baryal@umn.edu

Robert L. Dunbar, University of Minnesota-Rochester

We describe the design, implementation, and assessment of an activity intended to help undergraduate students understand concepts related to force and physiology by integrating physics in an anatomy and physiology classroom. The teaching/learning sequence involved electromyography (EMG) recordings and a model of an arm aimed to help students understand the relationship among load, force generated by the biceps, and the amplitude of EMG signals. The learning sequence was implemented and systematically modified to explore the impact of specific variables over three semesters. We have analyzed various assessments to measure the degree to which students successfully incorporate understanding of physics concepts when designing and performing the EMG lab and interacting with the physical model. We present how using different real-world scenarios affects student understanding and application of relevant physics concepts as well as describe challenges in teaching and learning of abstract quantitative skills in the contexts of life science courses.

PST1D05: 8:30-9:15 p.m. Energy Loss in Maxwell Rolling Pendulum System

Poster – Jixuan Hou, Southeast University, Department of Physics, Nanjing, 211189 P. R. China; jixuanhou@hotmail.com

JI Jing, Southeast University

We have analyzed the dynamics of ideal Maxwell rolling pendulum system and semi-quantitatively demonstrated the energy loss cased by different physical mechanisms. By measuring the variance of the maximum height that the pendulum can reach each time, we conclude that air friction is not the primary cause of energy loss of the system and the energy transfer to other degree of freedom might be the main reason of the energy loss.

PST1D06: 9:15-10 p.m. Basic Quantum Mechanics Concepts From the Eyes of Engineering and Physics Students!

Poster – Tugba Yuksel, Purdue University, West Lafayette, IN 47907-2040; tyuksel@purdue.edu

Yu Gong, Aljandra J. Magana, Purdue University

Rapid growth through broad swathes of the scientific and technological fields has been defining features of the last few decades, spurred on by revolutions in scientific thinking. Today, quantum mechanics is opening a new chapter in the scientific world, which reveals the extraordinary nature of numerous phenomena at the sub-atomic level. With the advent of increasing scientific policies worldwide to stay on the technological edge, quantum mechanics education has been in the limelight. To investigate how students formulate and conceptualize foundational quantum concepts in engineering and science learning, a phenomenographic study is designed to examine the knowledge structure and thinking process of students from different levels in engineering and physics departments. Through analyzing the semi-structured interview data, misconceptions and modeling strategies that students utilized to conceptualize unobservable or unaccountable phenomena were identified preliminary in this paper. The possible implications for instruction and curriculum design are also discussed.

PST1D07: 8:30-9:15 p.m. Introduction to Arduino Using High-Altitude (Weather) Ballooning Sensor Packs

Poster – James A. Flaten, University of Minnesota-Twin Cities, 107 Akerman Hall, SE Minneapolis, MN 55455; flate001@umn.edu

Seth Frick, Spencer McDonald, Christopher Gosch, University of Minnesota-Twin Cities

To introduce college students (and others) to Arduino microprocessors, we have developed a set of Arduino-based sensor packs for use on high-altitude (weather) balloon flights into the stratosphere, also called "near space" because the environmental conditions (and the view!) are similar to outer space. The sensor packs record physical data (temperature (potentially at multiple locations), atmospheric pressure, relative humidity, solar panel output (i.e. light intensity), 3-axis acceleration, and/or 3-axis magnetic field strength using a mixture of analog and digital sensors) every few seconds during a ~two-hour balloon flight. We then apply time stamps (and sometimes GPS stamps) and log the data to an SD card for later retrieval and analysis. Depending on the participants we build and program a "Basic Uno" package, a more-capable "Basic Mega" package, or a "Super Uno" package that really pushes the limits of an Arduino Uno microprocessor.

PST1D08: 9:15-10 p.m. Dealing with More Climate Myths

Poster– Gordon J. Aubrecht, Ohio State University at Marion, 193 North Washington St., Delaware, OH 43015-1609; aubrecht.1@osu.edu

Many scientists understand that climate change has a sociopolitical aspect, but some scientists are unwilling to address the issue lest they be perceived as political themselves. Nevertheless, when we scientists find climate myths, I think it is our duty as scientists to be willing to debunk them. A poster at Orlando on this topic was well received. This poster exhibits some more climate myths and contrasts them with the science.

PST1D09: 8:30-9:15 p.m. Making Collaboration Worth Your Time

Poster – Heather J. Moore, Robert E. Lee High School, Fairfax County PS, Arlington, VA 22206; heatherjeanmoore@gmail.com

Mark Hartman, Millbrook High School: Wake County PS, NC

Kate E. Miller, Washington-Lee High School: Arlington PS, VA

"Collaboration": a buzzword frequently used but infrequently made meaningful. We are a team of four teachers in three districts (two states) that has successfully collaborated for three years. This group has been invaluable in improving our instructional design and implementation of lessons. Together, we align content on a near daily basis, use backwards planning, and create common formative/summative assessments. Our success stems from our group norms—(1) a commitment to instructional alignment, (2) decisions made through consensus rather than majority, (3) a critical but respectful approach towards new ideas and (4) a reflective stance of our group processes. We will share tools, protocols, and technology that have allowed us to be effective and efficient in our collaboration. This team is supported by the Knowles Science Teaching Foundation which strives to support new science teachers in becoming expert teachers.

PST1D10: 9:15-10 p.m. Assessing Undergraduate Physics Program Learning Objectives at UC Merced

Poster – Carrie A. Menke, University of California, Merced 5200 N. Lake Rd., Merced, CA 95343; cmenke@ucmerced.edu

Establishing and assessing program learning objectives (PLOs) provides a research-based method to improve our undergraduate physics education. We have five PLOs: (1) physical principles, (2) mathematical expertise, (3) experimental techniques, (4) communication and teamwork, and (5) research proficiency. We use a six-stage assessment cycle for each PLO that either validates current practice or drives needed modifications to our assessment process and/or program. We focus on one PLO each year and have just finished our first assessment of each. Our approach strives to maximize the ease and applicability of our assessment practices while maintaining faculty's flexibility in course design and delivery. A curriculum matrix elucidates skills development and applicable evidence. Descriptive rubrics result in higher inter-rater reliability and, in some cases, can be utilized at the course and program levels. Utilizing existing campus resources, challenges with evidence & rubrics, and strategies for increasing student and faculty participation are also discussed.

PST1D11: 8:30-9:15 p.m. Workshop of Electric Circuits for Mexican Preschool Teachers

Poster – Mario Humberto Ramirez Diaz, CICATA-IPN Legaria 694, Col. Irrigación Mexico, MEX 11500 Mexico; mramirezd@ipn.mx

In the Mexican educational system, there is request for the preschool level to have scientific knowledge, applications of scientific knowledge and technology, skills associated with science, and attitudes associated to science. However, preschool teachers usually do not have these skills and therefore don't build strategies to develop in the kids this kind of competencies. On the other hand, professional physicists hardly approach elementary levels, especially in preschool, furthermore they didn't develop in their professional life didactic skills for the learning of physics. This situation take us to build workshops directed to preschool teachers in several topics of physics designed by physicists, so that the teachers could try to take this experience in their classroom with their students. We will show the results of the workshop in electric circuits with Mexican preschool teachers and their posterior implementation with the kids. It is useful to develop science skills not just with the teachers, but also with the parents and principals.

PST1D12: 9:15-10 p.m. What Japan's Urgent Development of Radiation Curricula Is Telling Us

Poster – Sachiko Tosa Niigata, University/Wright State University Faculty of Ed., Niigata University, Niigata 950-2181 JAPAN; stosa@ed.niigata-u.ac.jp

The disaster of the Fukushima Daiichi nuclear power plant after the huge earthquake on March 11, 2011, has shaken the standards of science education in Japan. People feared radiation because they knew almost nothing about it. Through the urgent effort by governmental agencies and highly motivated science teachers in Japan, a few curricula for teaching radiation for middle school students were developed in the past three years. In the process of curricula development, it became clear that Japan's science education at the middle-school level lacked teaching of 1) basic scientific knowledge about radiation, 2) effects of radiation on the human body, 3) risk and usefulness of radiation in society, 4) process skills to measure and interpret radiation level, and 5) history and actual examples of phenomena associated with radiation. This presentation will focus on what the physics education communities in the world can learn from this Japanese case.

PST1D13: 8:30-9:15 p.m. Toward a Balanced Undergraduate Curriculum: Theory, Computation, Experimentation, and Communication

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

Adam Green, Jeff Jalkio, Marie Lopez del Puerto, Paul Ohmann, Gerry Ruch, Elizabeth Wehner, University of St. Thomas

The University of St. Thomas Physics Department is engaged in an ambitious, collaborative project to effectively embed computation, experiment, and communication skills throughout the curriculum. Our sophomore-level modern physics sequence provides an introduction to experiment and computation, as well as informal and formal technical writing. We moved our advanced laboratory course forward in the curriculum to give students experimental design and instrumentation skills that they can build on, and so they can get involved in research early. Experimental skills are further developed in optics, with its rigorous laboratory. In many of our lecture-based courses we have added short computational and /or experimental projects that connect the idealized physical systems with real systems. In all courses, written and oral communication skills are improved through laboratory notebooks, papers, poster presentations, or talks. Through continued exposure, our students learn computational techniques, gain confidence in their experimental skills, and polish their communication skills.

PST1D14: 9:15-10 p.m. A Series of Modules for Introducing Computation into the Classroom and Laboratory

Poster – Jessie A. Petricka, Gustavus Adolphus College, St. Peter, MN 56082-1498; jpetrick@gustavus.edu

Presented are a series of modules for incorporating computation within the pedagogy in the classroom and laboratory. The modules serve both to introduce different computational platforms through intentional use of varied programs, (spreadsheet/Excel, symbolic/Mathematica, and LabView) and to teach concepts where those tools can be brought to bear. The concepts covered here are numerical integration via Euler's Method, error analysis and chi-square, and the use and understanding of a lock-in amplifier.

PST1D15: 8:30-9:15 p.m. Transitioning to "Department Chair" at a College of Pharmacy

Poster – Richard P. McCall, St. Louis College of Pharmacy, St. Louis, MO 63110-1088; rmccall@stlcop.edu

A recent restructuring at St. Louis College of Pharmacy has created a new Department of Basic Sciences. As the only physicist at the college, my appointment as department chair has led to some interesting challenges. How do I continue to teach full time, chair a major college committee, and chair the new department? How do I go from being a colleague to being a supervisor/boss? How do I fulfill administrative duties and lead the department? How do we change our thinking to include two new undergraduate degree programs and not just pre-professional education? Several exciting things are on the horizon: the department is hiring more faculty in all areas (biological sciences, chemistry, math, and physics), we are developing more BS degree programs, more physics is required in the new undergraduate curricula, and a new physics lab is planned.

PST1D16: 9:15-10 p.m. Using CFAs in Inquiry-based Middle School Science Teaching. I

Poster – Jennifer L. Esswein, Tennessee Department of Education, 710 James Robertson Pkwy., Nashville, TN 37243; jennifer.esswein@tn.gov

Caryn A. Palatchi, Ohio State University

Gordon J Aubrecht, Jessica G. Creamer, Ohio State University at Marion

Bill Schmitt, Science Center of Inquiry

As part of the Inquiry Model for Professional Action and Content-rich

Teaching III program (IMPACT III), teachers in a large Midwestern school district administer common formative assessments (CFAs) of science content to their middle and high school students. These assessments, created by the teachers for the purpose of informing their teaching, both assess and further develop student understanding of complex scientific content. This talk will focus on the development of a four-part rubric including evaluation of student reasoning, clarity, use of analysis, and correctness.

*Research 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), and ODE-MSP-10673 (2013-2014).

PST1D17: 8:30-9:15 p.m. Using CFAs in Inquiry-based Middle School Science Teaching. II*

Poster – Caryn A. Palatchi, Ohio State University, Columbus, OH 43210; palatchi.1@osu.edu

Jennifer L. Esswein, Tennessee Department of Education

Gordon J. Aubrecht, Jessica G. Creamer, Ohio State University at Marion

Bill Schmitt, Science Center of Inquiry

We analyzed common formative assessments (CFAs) administered to middle and high school students across a broad range of science subjects including biology, geology, physics, etc. For the analysis of CFAs, we established a rubric with four defining parameters: reasoning, clarity, analysis, and correctness.[1] Teachers worked with PER faculty to improve their teaching methodology and CFAs were used to analyze and quantify changes in student learning across the four rubric parameters that resulted from the intervention.

1. Esswein, Palatchi, Aubrecht, Schmitt, and Creamer, "Using CFAs in inquiry-based middle school science teaching.

* Research 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), and ODE-MSP-10673 (2013-2014).

PST1D18: 9:15-10 p.m. Analyzing Projectile Motion Uncertainty

Poster – Kent W. Scheller, University of Southern Indiana, Evansville, IN 47712; kschelle@usi.edu

Ian Parker, University of Southern Indiana

Projectile motion is one of the first core concepts demonstrated in the undergraduate laboratory and it provides an initial opportunity for students to learn uncertainty in measurements and the statistical analysis of data. Using the PASCO Projectile Launcher, students make multiple measurements of the range of a ball fired from the device. Inherent in the experiment are uncertainties in all variables used to make a theoretical calculation of the expected range. These uncertainties manifest themselves as an uncertainty in the calculated range. After multiple firings of the device, it is possible to experimentally determine the range with its associated statistical distribution. Here we compare the calculated uncertainty in the measurements of the range with the actual observed spread of the range data from 500 shots of the PASCO device. We use this exercise to emphasize the distinction between experimental uncertainty and statistical deviation in the measurement process.

E – Teacher Training and Enhancement

PST1E01: 8:30-9:15 p.m. AAPT Films – A New Video Series Created to Help Physics Teachers

Poster – James J. Lincoln, Tarbut V' Torah HS, 5 Federation Way, Irvine, CA 92603; James@PhysicsVideos.net

For the past year, I have been creating videos that are designed to both train new physics teachers and provide ideas and inspiration to experienced teachers. This poster describes and summarizes the AAPT Films Project and provides a chance for AAPT members to make requests and suggestions. This project was funded by the Meggers Award Grant and the Karl L. Brown Foundation. At the moment the videos are being hosted at www.youtube.com/aaptfilms.

PST1E02: 9:15-10 p.m. Guitars in the Classroom? Absolutely! Teaching Physics/STEM with Guitars

Poster – Debbie A. French, University of Wyoming/CAPER, Dept. 3374 Secondary Education, Laramie, WY 82070; frenchd14@yahoo.com

Thomas M. Huber, Gustavus Adolphus College

Richard M. French, Purdue University

Doug Hunt Southern, Wells Community Schools

Imelda Castaneda-Emenaker, University of Cincinnati

This study highlights the educational impacts from the 2010-2013 NSF-funded grant, "Faculty Professional Development in Design, Construction, Assembly and Analysis of a Solid Body Guitar Design," which provided innovative STEM professional development to high school and community college faculty. Workshop participants built their own custom solid-body electric guitar, engaged in and developed their own STEM learning activities related to the guitar to take back and implement in their classroom.

PST1E03: 8:30-9:15 p.m. ATE Workshops for Physics Faculty

Poster – Thomas L. O'Kuma, Lee College, Baytown, TX 77522-0818; tokuma@lee.edu

Dwain M. Desbien; Estrella Mountain Community College

The ATE Workshop for Physics Faculty project is into its fourth year and has finished its 19th 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.

PST1E04: 9:15-10 p.m. Using Gadgets & Gizmos in Phenomenon-based Learning

Poster – Matthew Bobrowsky, 11300 Classical Ln., Silver Spring, MD 20901; expert_education@rocketmail.com

Phenomenon-Based Learning (PBL) is a research-based approach designed to produce increased learning while making science education more engaging for the student and more interesting for the teacher. PBL arose from a collaboration with teachers in Finland, which is now seen as a major international leader in education. The PBL teaching philosophy combines elements of what's done in Finland with what's known about effective teaching based on science education research. The approach includes responsive teaching and inquiry-based collaborative learning, along with elements of problem-based learning, project-based learning, and hands-on experiments. The idea is to teach broader concepts and useful thinking and performance skills (as with NGSS) rather than asking students to simply memorize facts. By exploring first and getting to a theoretical understanding later, students are working like real scientists, having the opportunity to pursue creative approaches to understanding, learning more, and having fun in the process!

PST1E05: 8:30-9:15 p.m. Understanding and Explaining Equations in Physics Teacher Education

Poster – Ricardo Karam, University of Hamburg, Binderstraße 34 - Raum 21a Hamburg, HH 20146 Germany; ricardo.karam@uni-hamburg.de

In this work I describe a semester course given to pre-service physics teachers at the Technical University of Dresden. Its main goal was to address issues related to understanding and explaining physics equations. Besides lessons dedicated to general historical and epistemological reflections on the interplay between physics and mathematics, four equations traditionally taught in high school level (free fall, centripetal acceleration, simple pendulum and refraction law) were approached in the course. During instruction, the students were presented with different ways of deriving these equations and were given the task to explain each of them to the whole class. Using multiple data sources, which include pre-/post-instruction questionnaires, association maps and explanations' repertoire to each equation, interviews with selected students and the recording of the meetings, several aspects that influence students; understanding of these equations, as well as their views on how to explain them in classroom situations, were identified. The main findings of this study will be presented and discussed.

PST1E06: 9:15-10 p.m. "Is This Real Life": Mixed Reality Training for Learning Assistants

Poster - Jacquelyn J. Chini, University of Central Florida, Orlando, FL 32816; jacquelyn.chini@ucf.edu

Kevin H. Thomas, Malcolm B. Butler, Talat S. Rahman, 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. We used TeachLivE™ with a class of Learning Assistants (LAs), who worked in three-person groups. 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 with regards to their pedagogical skills, specifically use of questioning and formative assessment. We present findings about what the LAs and instructors learned from this unique environment that shows promise for enhancing the preparation of physics teachers.

PST1E07: 8:30-9:15 p.m. STEMteachersNYC – Starting an Effective Physics Teacher Support Organization

Poster – Fernand Brunschwig, Columbia University Teachers College, New York, NY 10027; fbrunsch@gmail.com

STEMteachersNYC, affiliated with the American Modeling Teachers Association, has achieved strong growth since its founding by a group of physics teachers in May, 2011, with a membership of 240 in February, 2014. The group has organized a total of 32 highly successful workshops between founding and February, 2014, including four three-week Summer Modeling Instruction Workshops and 28 three-hour weekend workshops. See STEMteachersNYC.org for details. This poster documents what we have achieved and describes the explicit organizing strategies and the process we used to generate our dynamic growth. STEMteachersNYC has successfully leveraged experienced teachers' expertise as workshop leaders and has been supported financially almost entirely through fees paid by the teachers attending the workshops. The poster explores in detail the scalability of what we have done, as well as the potential for widespread implementation to support teachers, especially beginners, by enhancing their pedagogic content knowledge and teaching skills.

PST1E08: 9:15-10 p.m. Recent Demographics of Physics Teachers from Schools and Staffing Survey

Poster – David Rosengrant, Kennesaw State University, Kennesaw, GA 30144; drosengr@kennesaw.edu

Greg Rushton, Gene Ray, Kennesaw State University

This project is part of a multidisciplinary team to study secondary physics teaching using the School and Staffing Survey (SASS) between 1987 and most recently 2011. We will investigate the following questions: How many physics teachers are there in the United States? What are trends in the population growth compared to other teacher groups in the past 20 years? What proportion of those that teach physics do so as their main assignment? What other subjects do physics teachers teach? To what extent have physics teachers earned a physics degree at any level? What other backgrounds do these teachers have? What has been the certification status of physics teachers over time? To what extent has the racial and gender profile of physics teachers changed over time? To what extent have the age and years of experience distributions changed over time? We will also analyze trends in early career physics teachers.

PST1E09: 8:30-9:15 p.m. Professional Development of Teacher and Master PFDS

Poster – Marisa Michelini, PERU - DCFA - University of Udine, via delle Scienze 208 Udine, 33100 Italy, marisa.michelini@uniud.it

Stefano Vercellati, PERU - DCFA - University of Udine

The Master "Professione Formatore in Didattica delle Scienze" (M-PFDS) (Formation Profession in Science Education) is a biannual course for expert teachers that will become responsible for the in-service education of science teachers in the first five years of the Italian secondary schools. The research-based M-PFDS implement an integrated model of those meta-cultural, experiential and situated for teacher professional development. Udine University carries it out in e-learning modality while three other Italian universities do it with courses in presence. It is based on school/university cooperation. Particular attention is placed to match the interdisciplinary nature of the science education to offer the participants a rigorous, certificated, and qualified formation based on the most recent development of the pedagogical content knowledge. Participants become competent in design-based research to be able to form other teachers to innovation in teaching/ learning process.

PST1E11: 8:30-9:15 p.m. Integrating Practices and Core Ideas into Introductory Physics Courses

Poster – James T. Laverty, Michigan State University, Lansing, MI 48910; laverty1@msu.edu

Marcos D. Caballero, Michigan State University

The current curriculum in most introductory college physics classes nationwide centers almost exclusively on content knowledge. Many recent national publications have called for an integration of scientific practices (e.g. Construct and Use Models) into the curriculum to teach students the process of science as well. In the Physics and Astronomy Department at Michigan State University, we are working with faculty to incorporate practices into the introductory physics courses. As part of this process, we are developing assessment items that integrate both the practices and core ideas of introductory physics. These items are being used as a stepping stone to develop curricular changes in the courses as well. This poster will focus on this development process and its current status.

PST1E12: 9:15-10 p.m. Instructors' Understanding of Physics Concepts Training Through in-lab Inquiry-based Oriented Model

Poster – Sergio Flores Garcia, University of Juarez, El Paso, TX 79912; seflores@uacj.mx

Maria C. Salazar, Jaun L. Gonzalez, Oscar Ruiz, Eduardo J. Loera, University of Juarez

Inquiry-based physics is integrating in-lab learning approaches. At the University of Juarez Mexico, we have established a physics teaching model based on instructors' abilities to explore and argue mechanics content ideas of the environment. They develop skills to design and implement their own in-lab learning activities through a 40-hour workshop in the physics lab. The frame of reference is a compound of five phases: 1) Design, 2) Preparation, 3) Experimentation, 4) Measure, and 5) Discussion. Instructors have to generate a general question, specific questions, and a hypothesis during the first phase. These questions and the hypothesis are the central axis of the cognitive strategy. The questions are designed to explore several taxonomy levels and foster the development of intellectual abilities and scientific skills. This instruction model will impact students' conceptual understanding. The rest of curriculum elements are: Pre-test, post-test, rubrics and an acceptance survey.

PST1E13: 8:30-9:15 p.m. Infusing Pedagogical Content Knowledge into Elementary Teacher Preparation*

Poster – Claudia Fracchiolla, Kansas State University, Manhattan, KS 66506; fracchiollac@ksu.edu

N. Sanjay Rebello, Kansas State University

Pedagogical Content Knowledge (PCK) is an important aspect in the preparation of future teachers. We have recently redesigned the Concepts of Physics (CoP) course for future elementary teachers at Kansas State University to infuse PCK into the learning experiences of the students. In this poster, we will describe how this course integrates the process of learning the physics concepts with learning of children's ideas about those concepts. The course is structured around the pedagogical learning bi-cycle (PLB), which combines the learning of content knowledge with knowledge of age-appropriate pedagogy. The integration is facilitated through a metacognitive reflection as a bridge between learning content and pedagogy. We will describe the structure of the course and provide examples of the activities of the course that have been used to facilitate students' metacognition and development of their PCK.

*This material is based upon work supported by the National Science Foundation under grant 1140855.

PST1E14: 9:15-10 p.m. Biology to Physics Teacher – Case Study

Poster – Judy Vondruska, South Dakota State University, Brookings, SD 57007; judy.vondruska@sdstate.edu

This intrinsic case study explores the process through which an experienced biology teacher becomes a high school physics teacher for the first time. Data gathered through interviews and evaluation of a personal journal focused on the teacher's preparation over the summer and the teacher's perceptions and practices during the first year of teaching the course. The results of this case study suggest that while many teaching practices can be transferred between disciplines, there is difficulty in building expertise in content knowledge. Additionally, while access to the Internet can reduce the isolation of a teacher teaching outside their discipline by providing numerous resources, a content novice does not have the experience or confidence to evaluate which materials are appropriate to use.

PST1E15: 8:30-9:15 p.m. Fostering Partnerships between Physics Departments and K-12 Teachers*

Poster – Jennifer L. Docktor, University of Wisconsin - La Crosse, La Crosse, WI 54601; jdocktor@uwlax.edu

Gubbi Sudhakaran, University of Wisconsin - La Crosse

Jerry Redman, Winona State University

The "A LOT of Science" project at the University of Wisconsin-La Crosse provides professional development (PD) in Physical Science to in-service elementary and middle school teachers from high-needs school districts during summer institutes and ongoing weekend workshops. The PD is designed to incorporate the Next Generation Science Standards into project activities. We will summarize findings from all three years of the project, including teacher gains in content knowledge, student achievement data, self-reported use of inquiry-based pedagogy, and additional impacts of the partnership.

*This project is funded by a U.S. Department of Education Mathematics and Science Partnerships Program grant through the Wisconsin Department of Public Instruction.

PST1E16: 9:15-10 p.m. Reforming Physics Teacher Education at the University of Wisconsin-La Crosse

Poster – Jennifer L. Docktor, University of Wisconsin-La Crosse, La Crosse, WI 54601; jdocktor@uwlax.edu

Gubbi Sudhakaran; University of Wisconsin-La Crosse

The University of Wisconsin-La Crosse (UW-L) Physics Department is nationally recognized as a thriving undergraduate physics program, and routinely ranks among the top producers of physics majors among bachelor's-only granting institutions. Despite its success at recruiting and retaining physics majors, UW-L graduates very few students licensed to teach high school physics. Recently, UW-L was selected as a targeted site by the Physics Teacher Education Coalition (PhysTEC) and has made focused efforts to increase the number of students pursuing careers in physics teaching. We will present a description of changes that have been made to improve physics teacher education at UW-L and evaluate the effectiveness of each initiative. Preliminary evidence suggests that the most successful practice for recruiting and retaining students in physics teaching has been focused advising and mentoring from faculty members.

*This project is funded in part by an award from the Physics Teacher Education Coalition (PhysTEC).

PST1E17: 8:30-9:15 p.m. Connecting Three Pivotal Concepts in K-12 Science State Standards and Maps of Conceptual Growth to Research in Physics Education

Poster – Chandralekha Singh, University of Pittsburgh, Pittsburgh, PA 15260; clsingh@pitt.edu

Chris Schunn, University of Pittsburgh

We discuss three conceptual areas in physics that are particularly important targets for educational interventions in K-12 science. These conceptual areas are force and motion, conservation of energy, and geometrical optics, which were prominent in the U.S. national and four U.S. state standards that we examined. The four U.S. state standards that were analyzed to explore the extent to which the K-12 science standards differ in different states were selected to include states in different geographic regions and of different sizes. The three conceptual areas that were common to all the four state standards are conceptual building blocks for other science concepts covered in the K-12 curriculum. We discuss the nature of difficulties in these areas along with pointers towards approaches that have met with some success in each conceptual area. We thank the National Science Foundation for support.

PST1E18: 9:15-10 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, 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. In particular, for each item on the TUG-K, the graduate students were asked to identify which incorrect answer choice they thought would be most commonly selected by introductory physics students if they did not know the correct answer after instruction in relevant concepts. We used the graduate student 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.

PST1E19: 8:30-9:15 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, Pittsburgh, PA 15217; 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. For each item on the FCI, the instructors and TAs were asked to identify the most common incorrect answer choice of introductory physics students. We also discussed the responses individually with a few instructors. Then, we 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

Session DA: Teaching the "Women in Physics" Course

Location: STSS 230
Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 29
Time: 8–10 a.m.

Presider: Juan Burciaga

DA01: 8-8:15 a.m. Teaching a Women and Science Course at Barnard College

Invited – Laura Kay, Barnard College, New York, NY 10027-6598; lkay@barnard.edu

I will discuss my course "Women in Science," which I have offered at Barnard College since 1992. The goals of the course are to familiarize students with the history, politics, and sociology of women's involvement with science. We begin by examining women's contribution to scientific discovery in various fields, and consider how women were affected by the professionalization of science and medicine. We look at the status of contemporary female scientists in the U.S. and the issues they encounter. We read accounts of contemporary women working as scientists and examine the science education of girls and women. We look at some of the feminist critiques of science as an institution and a methodology, and debate how these critiques apply differently to the biological and the physical sciences and whether they explain the variation of women's participation across different countries. We examine historical and contemporary 'scientific' ideas about gender, race, ethnicity and sexuality, and discuss the question of objectivity in science. We then consider how these relate to issues of women's participation in scientific endeavors.

DA02: 8:15–8:30 a.m. Why Aren't More Women in Science, and Is Physics Different?

Invited – Katherine Aidala, Mount Holyoke College, South Hadley, MA 01075; kaidala@mtholyoke.edu

I teach a course titled "Gender in Science" that attempts to answer the question, "Why aren't more women in science?" One major theme we address is how we must carefully identify what specific question individuals are trying to answer when following this broad line of inquiry, and how focusing on different fields within science might lead us to different answers. We mostly read primary literature from the social sciences, as well as review articles and reports from professional organizations and the government. Students learn to be critical readers of journal articles, applying the same standards to findings of discrimination as they do to papers that claim innate biological differences. Assignments include following up on a citation in a paper that we read for the course, and presenting this paper in class to their peers.

DA03: 8:30-8:45 a.m. Transformative Teaching Techniques: A Women's Studies Course for STEM Majors

Invited – Elizabeth Holden, University of Wisconsin-Platteville, 219 Engineering Hall, Platteville, WI 53818-3099; holdene@uwplatt.edu

This session will benefit educators who are looking for transformative teaching methods to develop a better understanding of gender issues, more knowledge and more strategies to become active in eliminating gender bias, specifically within the fields of physics and engineering. I will discuss strategies used to create a classroom environment where students can learn about and discuss issues related to women in science, technology, engineering, and mathematics (STEM). I will also discuss techniques to help college students understand the connection of these issues to their own lives, and how to introduce women and other underrepresented students to support networks.

DA04: 8:45-9 a.m. Teaching About Women in STEM: Understanding Race, Sexuality, and Many Identities Women Hold

Invited – Ramon Barthelemy, Western Michigan University, Ann Arbor, MI 48105; ramon.s.barthelemy@gmail.com

Tuesday, July 29 Highlights

REGISTRATION	7 a.m.–4:30 p.m.	Coffman Union ground floor
Fun Run/Walk	6:30–8 a.m.	offsite
2-Year Coll. Breakfast	7–8:30 a.m.	Coffman Union President's
Exhibit Hall Open	10 a.m.–4 p.m.	Coffman Union Great Hall
Gift Card Raffle	10:15 a.m.	Coffman Union Great Hall

KLOPSTEG AWARD 10:30–11:30 a.m.
Donald Olson **Northrop Auditorium**

APS PLENARY 3:30–5 p.m. Northrop Auditorium

COMMERCIAL WORKSHOPS

PASCO	11:30-12:30	STSS 131B
OpenStax College	11:30-12:30	STSS 432A
Perimeter Institute	11:30-12:30	STSS 131A
Vernier Software	11:30-12:30	Coffman President's
WebAssign	11:30-12:30	STSS 119
Liti Holographics	11:30–1 p.m.	STSS 530A
Expert TA	12–1 p.m.	Coffman Mississippi
Perimeter Institute	1–2 p.m.	STSS 131A

COMMITTEE MEETINGS, 11:30–1 p.m.

–Laboratories	STSS 420B
–History and Philosophy	STSS 512B
–Pre High School Educ.	STSS 432B
–PER (RiPE)	Tate Lab 133
–Two-Year Colleges	STSS 512A

Easy JavaScript Simulations	12–1 p.m.	STSS 420A
Afternoon Break	3–3:30 p.m.	Coffman Union Great Hall
iPad Mini drawing	3:15 p.m.	Coffman Union Great Hall
Poster Session 2	5–6:30 p.m.	Coffman Union ground floor

Trolley Tour of Minneapolis 6:30–7:30 p.m.

Demo show 8–9 p.m. Willey Hall

Pub Crawl
10 p.m.–1 a.m. (starts in lobby of Marriott)

Too often in the conversation of women in physics and STEM women are assumed to hold one all encompassing identity. Inevitably this identity is derived from the lives of upper-class heterosexual white women from educated homes. Rarely does the imagery of women scientists include people of color, lesbians, transwomen, or women from low socio-economic status. When teaching courses on gender and physics it is imperative that we include research, examples, and stories from the lives of diverse women. Rebranding physics as a potential home for many varied identities is critical for the success of the field. Starting this conversation in the classroom may be one tool to support the diversification of physics, particularly for women.

DA05: 9-10 a.m. A Women in Mathematics, Computer Science, and Physics Course*

Poster – Jim Crumley, College of Saint Benedict / Saint John's University, 107 PE Science Center, Collegeville, MN 56321-2000; jcrumley@csbsju.edu

Kris Nairn, Lynn Ziegler, Yu Zhang, Pam Bacon, College of Saint Benedict / Saint John's University

Increasing women's participation is a concern in disciplines beyond physics. As part of our Mathematics, Physics, Computer Science Research Scholars (MapCores) program,[1] we teach a women in science class covering these three areas. Our course is a special version of our college's first year seminar, which is a course designed to prepare our students to read, write, and speak at a college-level. We structure our FYS to promote academic confidence and interest in our disciplines for the women in MapCores. It covers not only contributions that women have made and barriers that women face in these disciplines, but also research frontiers and science policy issues in these disciplines. While the women in MapCores find covering these topics beneficial, the most important benefit of the course is the supportive cohort that grows from it.

1. (http://www.csbsju.edu/mapcores/) *Supported by NSF grant DUE-0965705.

DA06: 9-10 a.m. Preliminary Work in Developing a Women in Physics Freshman Seminar

Poster – Jolene L. Johnson, St. Catherine University, St. Paul, MN 55105; jljohnsonarmstrong@stkate.edu

St. Catherine University is a small all women's liberal arts college, looking to add a physics major for the first time. The number of potential students is a consideration when adding programs so we are exploring ways to increase the number of women interested in majoring in physics and their persistence. In the future we plan to offer a freshman seminar that focuses on women in physical sciences. This class would cover the topics currently covered in freshman seminar but would also include topics such as historic women in science, differences in learning styles, and discrimination in STEM. We believe that the community this class would build along with the discussions would improve the retention of STEM majors. In this poster we will present student comments and reactions to a pilot discussion that occurred in introductory physics. We will also outline the potential topics and structure of this course.

Session DB: Sustainability of Physics Teacher Prep Programs

Location: STSS 114
Sponsor: Committee on Teacher Preparation
Date: Tuesday, July 29
Time: 8–10 a.m.

Presider: Monica Plisch

DB01: 8-8:30 a.m. Sustained Programs in Physics Teacher Education

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

Renee Michelle Goertzen, Monica Plisch, American Physical Society

For over a decade, physics teacher education programs have been transformed at a number of institutions around the country through support from the Physics Teacher Education Coalition (PhysTEC), led by the APS in partnership with the AAPT. In 2012-2013, PhysTEC supported an independent study on the sustainability of its sites after project funding ends. The study sought to measure the extent to which programs have been sustained and to identify what features should be prioritized for building sustainable physics teacher education programs. All of the studied sites that sustained their production of physics teachers have a champion of physics teacher education and corresponding institutional motivation and commitment. The necessity of the champion was known from the Report of the Task Force on Teacher Education in Physics (T-TEP report) and borne out by this study. The necessity of institutional motivation and commitment is a finding of this study.

DB02: 8:30-9 a.m. Driving Florida International University's Commitment to Physics Teacher Preparation

Invited – Laird Kramer, Florida International University, Department of Physics, Miami, FL 33199; kramerl@fiu.edu

Florida International University's Physics Department revitalized FIU's physics teacher preparation program through a Physics Teacher Education Coalition (PhysTEC) Primary Partner award in 2007. The PhysTEC project started an undergraduate Learning Assistant (LA) program at FIU and provided impetus to reorganize FIU's science and mathematics teacher preparation programs into discipline-based programs. Over the past seven years, strategic advocacy and leadership has built an institutional commitment to teacher preparation that has resulted in an institution-wide LA program supporting over 150 LAs serving in six disciplines, five discipline-based teacher preparation programs, and significant external funding. These efforts laid the foundation for awarding of FIUteach, a UTeach replication project, in 2014. An overview of the critical steps and vital partnerships will be presented.

DB03: 9-9:30 a.m. Sustainability: Obtaining Department Buy-In*

Invited – Gay B. Stewart, University of Arkansas, Department of Physics, Fayetteville, AR 72701; gstewart@uark.edu

John C. Stewart, University of Arkansas

Physics teacher preparation is the responsibility of physics departments, since those are the institutional units that provide physics education to university students. It is also a primary requirement for physics' long-term health in these days of the medical sciences' dominance. Still, some departments do not fully commit to this mission! At the University of Arkansas, one of the first PhysTEC sites, a model tied to two "champions" gained strong institutional support and is in a transitional phase of obtaining broader departmental support. The key to departmental buy-in has always been the appeal of the improvements to things traditionally important to the department, an improved undergraduate program and significant positive attention from administration. Cultivating the next generation of leadership has been an ongoing effort. Understanding what makes a "champion," and distributing this among faculty willing to commit some time and effort, but who have other primary passions, is the key.

*This work was made possible in part by the NSF and FIPSE as part of the first PhysTEC grant.

DB04: 9:30-10 a.m. Sustaining a Physics Teacher Preparation Program at a Major Research University: Challenges and Strategies

Invited – Laurie McNeil, University of North Carolina at Chapel Hill, Phillips Hall, Chapel Hill, NC 27599-3255; mcneil@physics.unc.edu

Most research-intensive universities do not regard teacher education as being a strong part of their missions, and students who choose to attend them rarely do so with the intention of becoming high school teachers (and may not receive much encouragement from faculty to select such a career path). Further, only a small fraction of students will choose to major in physics. This means that a physics teacher preparation program at a major research university might expect its output to constitute less than a tenth of a percent of the students who receive undergraduate degrees in a given year. For such a program to be sustained, it needs (at least) two things: bigger partners, and ancillary missions. I will discuss how at UNC-CH we have formed strong partnerships across the science departments, and have embedded our program into the educational life of the College of Arts & Sciences, allowing it to thrive even though we graduate only a small number of (excellent!) physics teachers.

Session DC: Broader Perspectives on Research in Learning Quantum Mechanics

Location: STSS 312
Sponsor: Committee on International Physics Education
Co-Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 29
Time: 8–10 a.m.

Presider: Genaro Zavala

DC01: 8:30-9 a.m. Integrating Concepts, Multimedia, and Applications in Curricula for Quantum Mechanics

Invited – Manjula D. Sharma, University of Sydney, School of Physics, NSW 2006 Australia; m.sharma@physics.usyd.edu.au

Significant research effort is dedicated to student learning of quantum mechanics from the perspective of concepts, multimedia, and applications. Our research covers this landscape for both school and university curricula. An emergent finding from our studies is that a shifting focus through Schwab's common places (learner, teacher, subject matter and milieu) balances as well as enriches the learning cycle. This innovative curriculum design will be illustrated by two examples using "video slices" based on the Brunner cycle. The first example, Meissner effect, has been trialled with university students and in schools, while the second, MRI in medical imaging, with schools. The role of whole class discussions compared with small group work, as well as prior knowledge will be discussed. This curriculum design has been successfully implemented across selected topics in physics; those that are difficult to teach and/or poorly resourced. The resources are widely used in senior high school physics across the state.

DC02: 8-8:30 a.m. Improving Students' Understanding of Quantum Mechanics

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

Learning quantum mechanics is challenging, in part due to the abstract nature of the subject. We have been conducting investigations of the difficulties that students have in learning quantum mechanics. To help improve student understanding of quantum concepts, we are developing quantum interactive learning tutorials (QuILTs) as well as tools for peer-instruction. The goal of QuILTs and peer-instruction tools is to actively engage students in the learning process and to help them build links between the formalism and the conceptual aspects of quantum physics without compromising the technical content. They focus on helping students integrate qualitative and quantitative understanding, and discriminate between concepts that are often confused. In this talk, I will discuss a theoretical framework to understand students' difficulties with quantum mechanics and give examples of how students' prior knowledge relevant for quantum mechanics can be assessed, and how learning tools can be designed to help students develop a robust knowledge structure and critical thinking skills.

DC03: 9-9:10 a.m. The UK Institute of Physics Quantum Physics Resources

Contributed – Derek Raine, University of Leicester Centre for Interdisciplinary Science, Leicester, LE1 7RH United Kingdom; jdr@le.ac.uk*

The Quantum Physics project quantumphysics.iop.org of the UK Institute of Physics aims to support a modern approach to the teaching of introductory quantum mechanics based on two-level systems. The freely available online instructional materials include texts written by experts in the field, interactive simulations, activities and problems, with multiple paths through the material. This approach immediately immerses students in quantum phenomena that have no classical analog, using simpler mathematical tools that allow a greater focus on conceptual understanding. It allows from the start a discussion of interpretative aspects of quantum mechanics and quantum information theory. This presentation will give an overview of the online resources and the rationale behind the project.

*Sponsored by Antje Kohnle

DC04: 9:10-9:20 a.m. Interactive Simulations to Support Quantum Mechanics Learning and Teaching

Contributed– Antje S. Kohnle, University of St. Andrews, School of Physics and Astronomy, St Andrews, KY16 9SS UK; ak81@st-andrews.ac.uk

The QuVis Quantum Mechanics Visualization project (www.st-andrews.ac.uk/physics/quvis) consists of research-based interactive simulations with accompanying activities for the learning and teaching of quantum mechanics at university level. Simulations support model-building by reducing complexity, focusing on fundamental ideas and making the invisible visible. They promote engaged exploration, sense-making, and linking of multiple representations, and include high levels of interactivity and direct feedback. This presentation will give an overview of the QuVis simulations embedded in the Institute of Physics Quantum Physics resources and describe recent evaluation efforts using student surveys and pre- and post-tests to assess learning gains. It will also describe recent work on further simulation development, including the move to HTML5. QuVis is supported by the UK Institute of Physics, the UK Higher Education Academy and the University of St. Andrews.

DC05: 9:20-9:30 a.m. Quantum Interactive Learning Tutorial (QuILT) on Larmor Precession of Spin

Contributed – Benjamin R. Brown, University of Pittsburgh, 100 Allen Hall, Pittsburgh, PA 15260; brb10@pitt.edu

Chandralekha Singh, University of Pittsburgh

We have been conducting research to develop and assess a quantum interactive learning tutorial (QuILT) on Larmor precession of spin to help students learn about the 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 National Science Foundation.

DC06: 9:30-9:40 a.m. Quantum Interactive Learning Tutorial (QuILT) on Quantum Eraser

Contributed – Emily M. Marshman, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We are developing and assessing a quantum interactive learning tutorial (QuILT) on quantum erasure. The quantum eraser apparatus uses a Mach Zehnder Interferometer with single photons, and exposes students to contemporary applications of quantum mechanics. The QuILT strives to help students develop the ability to apply quantum principles in physical situations, explore differences between classical and quantum ideas, and organize knowledge hierarchically. The QuILTs adapt existing visualization tools to help students build physical intuition about non-intuitive quantum phenomena. Details of the development and assessment will be discussed. This work is supported by the National Science Foundation.

DC07: 9:40-9:50 a.m. Quantum Interactive Learning Tutorial (QuILT) on Quantum Key Distribution

Contributed – Seth T. DeVore, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260-3583; std23@pitt.edu

Chandralekha Singh, University of Pittsburgh

We have been conducting research and developing and assessing a quantum interactive learning tutorial (QuILT) on quantum key distribution to expose students to contemporary and exciting 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 using single photons with non-orthogonal polarization states and 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.

DC08: 9:50-10 a.m. Quantum Mechanics Online for Non-Physics Students*

Contributed – Dean A. Zollman, Kansas State University, Manhattan, KS 66506-260;1 dzollman@phys.ksu.edu

Raiya Ebini, Kansas State University

About 15 years ago the Visual Quantum Mechanics project created a series of research-based teaching/learning units to introduce quantum physics to a variety of audiences who normally would not study these topics. Interactive computer visualizations coupled with hands-on experiences created a student-centered series of activities. The instructional materials address a variety of concepts in quantum physics and applications to devices such as the light emitting diode. Whenever possible the students begin the study of a new concept with activities. They then build models of the physical phenomenon using interactive computer visualizations and conclude by applying those models to new situations. The original paper-and-pencil lessons and the visualizations are now freely available at http://web.phys.ksu.edu/vqm/. We are extending these activities to an online environment. We are modifying some of our teaching-learning strategies but we have been able to take advantage of the many web-based resources now available to build a research-based course.

*Supported by the National Science Foundation and the KSU Division of Continuing Education

Session DD: Assessment Issues in Undergraduate Instruction

Location: STSS 330
Sponsor: Committee on Research in Physics Education
Co-Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 29
Time: 8–10 a.m.

Presider: Eleanor Sayre

DD01: 8-8:30 a.m. Research-based Assessment Resources to Improve Teaching in Your Classroom and Department

Invited – Sarah B. McKagan, American Association of Physics Teachers, College Park, MD 20740-3845; smckagan@aapt.org

Adrian Madsen, American Association of Physics Teachers

Eleanor C. Sayre, Kansas State University

Often physics faculty want to know how their students are doing compared to other "students like mine." As part of the PER User's Guide (http://perusersguide.org), we are developing a national database of research validated assessment results and an accompanying data explorer. Here faculty can securely upload their students' anonymized assessment results and compare them to students from peer institutions and the national dataset, view a question-by-question breakdown and compare results over time. "One-click analysis" allows faculty to visualize their data, view statistics and download a report of the results. Results can be used to improve teaching, to make a case for more resources, for accreditation reports, or for promotion and tenure. Additionally, we are developing guides to these research validated assessments and access to the tests themselves. We will showcase our new online system and provide information about how you can use it.

DD02: 8:30-9 a.m. Coupled Multiple-response vs. Free-response Formats in Upper-division Conceptual Assessment

Invited – Bethany R. Wilcox, University of Colorado Boulder, 2510 Taft Dr. Unit 213, Boulder, CO 80302; Bethany.Wilcox@colorado.edu

Steven J Pollock, University of Colorado Boulder

Free-response conceptual assessments, such as the Colorado Upper-division Electrostatics Diagnostic (CUE), provide rich, fine-grained information about students' reasoning. However, because of the difficulties inherent in scoring these assessments, the majority of the large-scale conceptual assessments in physics are multiple-choice. To increase the scalability and usability of the CUE, we set out to create a new version of the assessment that preserves the insights afforded by a free-response format while exploiting the logistical advantages of a multiple-choice assessment. We used our extensive database of responses to the free-response CUE to construct distractors for a new version where students can select multiple responses and receive partial credit based on the accuracy and consistency of their selections. Here, we briefly outline the development of this new coupled, multiple-response CUE. We also discuss a direct comparison of test statistics for both versions of the assessment and potential insights into student reasoning from the new version.

DD03: 9-9:30 a.m. Mathematization in Introductory Physics through a Socioeconomic Lens

Invited – Suzanne Brahmia, Rutgers University, Department of Physics and Astronomy, Piscataway, NJ 08854-8019; brahmia@physics.rutgers.edu

Conceptual understanding of arithmetic and algebra (taught before students reach high school) is essential to effective reasoning in college physics.[1] Instructional approaches in pre-high school mathematics classes vary with SES (socioeconomic status); lower SES districts are more likely to promote rote learning.[2] Along with demographics, the Math SAT, which correlates with family income, is an important predictor of success in college physics.[3] Students from low SES districts are at a disadvantage in physics learning partially due to an overemphasis on procedure in their pre-college science and mathematics problem solving. An ongoing collaboration between Rutgers, WWU, and NMSU is developing assessment tools to measure facets of foundational mathematical reasoning in physics, and a curricular intervention to help develop these facets in a physics context. I'll describe these projects and share performance data comparing students from low SES high schools to those from more affluent schools in the freshman engineering physics course.

1. B.L. Sherin, "How students understand physics equations," *Cognition and instruction* **19**, 479–541 (2001).
2. J. Anyon, "Social Class and School Knowledge," *Curriculum Inquiry*,. **11**, No. 1. (Spring, 1981), pp. 3-42.
3. P.M. Sadler & R.H. Tai, "Success in introductory college physics: The role of high school preparation," *Science Educ.* **85**, 111-136 (2001).

DD04: 9:30-9:40 a.m. Use of Pre-instruction Tests to Predict Student Course Performance*

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

I will review research related to use of pre-instruction diagnostic tests such as the Force Concept Inventory as predictors of student course performance in introductory physics. In addition to both old and new data from Arizona State University, I will examine data from other institutions, both published and unpublished. I will explore both potential benefits and limitations of using pre-instruction data as prognostic measures of student performance. In particular, I will address the potential influence of instructional method on the predictive value of diagnostic tests, such as whether research-based active-learning instruction[1] might or might not significantly alter the observed pre-post correlation.

*Supported in part by NSF DUE #1256333

1. D. E. Meltzer and R. K. Thornton, "Resource Letter ALIP-1: Active-Learning Instruction in Physics," *Am. J. Phys*. **80**, 478 (2012).

DD05: 9:40-9:50 a.m. Assessment in Jr. Physics Laboratory

Contributed – Karen A. Williams, East Central University, Ada, OK 74820; kwillims@mac.com

My institution began a new assessment plan for the physics major about 18 months ago. This plan requires the assessment of the Junior Lab students' communication (written, verbal and graphical), their ability to apply their knowledge to applications in each lab, the evaluation of a design lab, and their ability to work in a team. I will share the rubrics that I have borrowed, modified, and created to implement this assessment the past two semesters.

DD06: 9:50-10 a.m. Assessing Undergraduate Physics Program Learning Objectives at UC Merced

Contributed – Carrie A. Menke, University of California, Merced, 5200 N. Lake Rd., Merced, CA 95343; cmenke@ucmerced.edu

Establishing and assessing program learning objectives (PLOs) provides a research-based method to improve our undergraduate physics education. We have five PLOs: (1) physical principles, (2) mathematical expertise, (3) experimental techniques, (4) communication and teamwork, and (5) research proficiency. We use a six-stage assessment cycle for each PLO that either validates current practice or drives needed modifications to our assessment process and/or program. We focus on one PLO each year and have just finished our first assessment of each. Our approach strives to maximize the ease and applicability of our assessment practices while maintaining faculty's flexibility in course design and delivery. A curriculum matrix elucidates skills development and applicable evidence. Descriptive rubrics result in higher inter-rater reliability and, in some cases, can be utilized at the course and program levels. http://www.aapt.org/test/forms/aaptmeeting/pactools/chairtool-abstracts.cfm?listorder=s2Utilizing existing campus resources, challenges with evidence & rubrics, and strategies for increasing student and faculty participation are also discussed.

Session DE: Developing Experimental Skills in the Introductory Lab

Location: STSS 412
Sponsor: Committee on Laboratories
Date: Tuesday, July 29
Time: 8–10 a.m.

Presider: Mary Ann Klassen

DE01: 8-8:30 a.m. First-Year Undergraduate Physics Labs: Constructing Knowledge and Understanding of Science

Invited – Paul van Kampen, CASTeL & School of Physical Sciences, Dublin City University, Dublin 9, Ireland; Paul.van.Kampen@dcu.ie

We have restructured the first-year undergraduate physics labs which cater for >300 non-physics majors. The labs were designed to be an enjoyable experience that helps students develop transferrable experimental skills, scientific skills (hypothesis testing, controlling variables, interpreting and drawing conclusions from their own experimental data), see science as a process of inquiry, address some conceptual difficulties, and enable them to carry out quasi-independent investigations. Over the course of a semester, the labs become less guided and less scaffolded while the students are given increasing levels of autonomy. Online pre-tests along with weekly surveys are used to assess the student's attainment, attitudes, experiences, and conceptual development. Student feedback has shown that the labs have been transformed into a more enjoyable experience where transferable experimental skills are developed. In this talk I will present an overview of the labs, where they have been successful, and aspects that need to be further developed.

DE02: 8:30-8:40 a.m. Weaving Experimental Skills Throughout the Introductory Laboratory

Contributed – John W. Zwart, Dordt College, Sioux Center, IA 51250; john.zwart@dordt.edu

The laboratory portion of an introductory course sequence can be used to meet a wide variety of goals ranging from illustrating phenomena studied in class, to building intuition about how the physical world works, to confronting the unexpected. Helping students develop experimental skills is a crucial goal that needs to be addressed in lab, especially in light of the fact that most introductory textbooks do not specifically address this topic. Important skills that students should learn in lab include how to analyze data, how to communicate results and the art of designing an experiment. This presentation will discuss how we weave an experimental skills thread through our introductory lab sequence in order to help students develop these key skills. See http://homepages.dordt.edu/zwart/ for implementation details.

DE03: 8:40-8:50 a.m. Structured Progression in a Sophomore-level Experimental Physics Course

Contributed – Ananda Shastri, Minnesota State University Moorhead, 1104 7th Ave. South, Moorhead, MN 56563; shastri@mnstate.edu

What is the best way to structure increasing complexity into a sophomore-level experimental physics course? A set of experiments used at Minnesota State University Moorhead will be described. The course revolved around the central question: what is the criterion for two measurements to be considered significantly different? Before the semester began, key ideas from the student lab manual, textbook, and homework problems were prioritized. Experiments were classified as beginning, intermediate, and advanced. Expectations of student performance were gradually increased. An example of course's structured progression will be given from oscilloscope training to the construction of an electrocardiogram monitoring system.

DE04: 8:50-9 a.m. Developing Design Skills in the Introductory Lab

Contributed – Joseph F. Kozminski, Lewis University, Romeoville, IL 60446; kozminjo@lewisu.edu

Building design skills into the introductory lab can be challenging for a variety of reasons. For example, the laboratory activities need to be well-scaffolded, and additional mentoring is needed during the lab periods so that the students are challenged but not unduly frustrated with their laboratory experience. For the last two years, much work has gone into restructuring the introductory lab and redesigning many of the laboratory activities to include design elements at Lewis University. In this talk, the design-related lab goals, some of the laboratory activities, and the mentoring required in such a lab will be discussed. How incorporating a design component has impacted the development of other important skills like collaboration, troubleshooting, making measurements, data analysis, and error analysis will be considered. And preliminary E-CLASS results indicating some early success in implementing these labs will be presented.

DE05: 9-9:10 a.m. Developing Data Analysis Skills Using Scientific Learning Community Labs

Contributed – Adam C. Lark, University of Toledo, Toledo, OH 43606; adam.lark@rockets.utoledo.edu

Scientific Learning Community (SLC) Labs were implemented for The University of Toledo's calculus-based introductory physics class. Students in these laboratories must design their own experiments, take meaningful data, and analyze that data to make conclusions about the concepts they are learning in laboratory that day. Interviews were conducted on students in both our traditional laboratories and SLC laboratories at the beginning and end of the semester. Interviewers asked students questions about how they would interpret and process a set of data. Using the hierarchy developed by Fred Lubben, these interviews were coded and compared showing the development of students' understanding of uncertainty and data analysis skills through the semester.

DE06: 9:10-9:20 a.m. ISLE-inspired Pilot Program at Princeton University: Year One Results

Contributed – Katerina Visnjic, Princeton University, Department of Physics, Princeton, NJ 08544-1098; visnjic@princeton.edu

Carolyn D. Sealfon, Evelyn H. Laffey, Princeton University, Council for Science and Technology

In an effort to enhance the traditional calculus-based introductory physics course at Princeton University, an Investigative Science Learning Environment (ISLE) inspired pilot program is under way. In the first year, two lab sections performed ISLE-inspired labs and activities in class, while the remaining 10 sections received traditional instruction. We strove for a random selection of students. To assess the effectiveness of the pilot program, we conducted focus interviews to probe how students felt about the course and how relevant it was in their everyday lives. We chose a variety of interviewees based on final first-semester grade, gender, opting in, and opting out. In this talk, we will describe in more detail the pedagogical approach used in the experimental sections. Using the interviews and more quantitative data, we will compare student learning in the experimental sections with the traditional sections. We will conclude with future plans.

DE07: 9:20-9:30 a.m. Estimating Uncertainties Using Upper-Lower Bounds

Contributed – Duane L. Deardorff,The University of North Carolina-Chapel Hill, Chapel Hill, NC 27599-3255; duane.deardorff@unc.edu

In our introductory physics laboratories at UNC-Chapel Hill, we have encouraged students to use a simplified approach to propagating measurement uncertainties using upper and lower bounds. In many cases, this approach is easier and more intuitive than the more traditional method of combining uncertainties in quadrature based on the propagation of error equation that utilizes partial derivatives. While this latter method is generally more accurate and consistent with the ISO Guide to the Expression of Uncertainty in Measurement (GUM), the upper-lower bound method does not require calculus and yields uncertainty values that are similar in magnitude, especially when rounding to one significant figure. The pros and cons of this alternative approach will be shared.

DE08: 9:30-9:40 a.m. Using Student's t-scores to Teach Measurement, Uncertainty, and Experimentation Skills

Contributed – Natasha G. Holmes, University of British Columbia, Vancouver, BC V6T 1Z1 Canada; nholmes@phas.ubc.ca

D A. Bonn, University of British Columbia

Many introductory physics labs ask students to conduct experiments to see or experience physics concepts from class first hand. Students collect data from these experiments and are expected to analyze the data to make sense of the physics equations they've learned in class. In first year, however, many of the students have little to no background in statistics. In addition, they enter the first year lab with misconceptions about the nature of measurement, uncertainty, and variability. This provides significant limitations to engaging students with physics concepts and developing experimentation skills. In the first-year honours physics lab at UBC, we have removed the conceptual physics learning goals from the course and replaced them exclusively with goals for learning data analysis and measurement skills. This year in particular, we have introduced the Student's t-test to the course material as a way to engage students in meaningful reflection of their results and to promote iterative experimentation. This talk will present some of these learning goals and new teaching techniques, as well as evidence of students' improved skills over previous iterations of the lab.

DE09: 9:40-9:50 a.m. Testing Results from Fictitious Papers

Contributed – John M. Welch, Cabrillo College, Aptos, CA 95003; jowelch@cabrillo.edu

Students can get used to looking for the "right answer" in labs and often ask us things like "is a 15% error close enough?" We'd like to teach them about the excitement of unexpected results and give them the skills to recognize when an experiment is inconsistent with theory. One way to do this is to have students try to replicate results from fake (or real) papers. In doing so, they refine experimental technique, analyze data, and collaborate in order to make decisions about proposed theories. Examples of these labs, sometimes called Falsification Labs, will be presented.

DE10: 9:50-10 a.m. From Open Source Electronics to Open Lab Curricula

Contributed – Zengqiang Liu, St. Cloud State University, St. Cloud, MN 56301; zliu@stcloudstate.edu

Acquiring analytical and experimental skills takes time and hands-on practice, including exploration and making mistakes. Formal laboratory alone is insufficient, which only averages two hours per week and is often too scripted. To solve this problem, we need a laboratory curriculum that emphasizes abundant supplemental hands-on, exploratory, and self-paced laboratory activities where students acquire their skills that may be assessed in formal laboratory. Supporting supplemental activities requires unrealistic amount in lab space and off-the-shelf apparatus. We present a viable solution: a low-cost open source electronic data acquisition platform. This AAPT award-winning platform will enable students to practice and explore physics in their own homes and at their own paces, opening the often closed-door of formal laboratory. It will enable instructors to design new curricula that focus on activities that build student skills. Some activities and curriculum development ideas will be discussed.

Session DF: Stories, Replicas, & Kits

Location: Tate Lab 170
Sponsor: Committee on History and Philosophy in Physics
Co-Sponsor: Committee on the Interests of Senior Physicists
Date: Tuesday, July 29
Time: 8–9:30 a.m.

Presider: Roger Stuewer

DF01: 8-8:30 a.m. Sparks and Shocks: Using Replicas of Historical Instruments in Museum Education

Invited – David J. Rhees, The Bakken Museum, 3537 Zenith Ave., Minneapolis, MN 55416; rhees@thebakken.org

We discuss various ways in which The Bakken Museum makes use of replicas or simulations of historical instruments, experiments, and demonstrations in education programs and exhibits for schools, families, and other audiences. Collaboration in the 1980s with Prof. Samuel Devons, Barnard, resulted in a series of institutes for high school science teachers incorporating historical simulations, also an "18th Century Electricity Kit" for middle school. Beginning in the early 1990s, versions were successfully integrated into field trips, then somewhat into school-based outreach in the late 1990s, studying static electricity, batteries/bioelectricity, and magnetism/electromagnetism. "Science theater" programs such as puppet shows, first-person interpretations (Ben Franklin, Mary Shelley), and short plays ("War of the Currents") also utilize historical simulations. A new exhibit, "Ben Franklin's Electricity Party," uses 18th century instruments to engage visitors. We analyze these programs' effectiveness, historical authenticity, comparison with programs elsewhere, and integration with historiography.

DF02: 8:30-9 a.m. Scientific Instruments and Philosophical Toys: The Blending of Science, Art, and Culture

Invited – Donald Metz, University of Winnipeg, 515 Portage Ave., Winnipeg, MB R3J 3C1 Canada; d.metz@uwinnipeg.ca

Peter Heering, Flensburg University, Flensburg, Germany

The role of scientific apparatus and experimentation is well known to physics educators. Today, in modern classrooms, our students have access to a wide range of such materials. However, historically, many scientific devices were adapted to provide amusement in parlor games and as children's toys. These "philosophical toys" were intended to raise questions about natural phenomenon and foster an understanding of new scientific principles. In this paper, we will pull back the curtain of achievements of people like the physicist Charles Wheatstone and suggest that many of their accomplishments and stories can be used in the teaching of science, especially in terms of the blending of art, culture, and science.

DF03: 9-9:30 a.m. An Optical Outreach Kit for School and Community Outreach

Invited – Justin Spencer, The Bakken Museum, 3537 Zenith Ave., Minneapolis, MN 55416; spencer@thebakken.org

Steven Walvig, The Bakken Museum

Martin Wolk, 3M Corporation

We present a collaborative effort between 3M and The Bakken Museum to create a science encouragement kit for the 3M Visiting Wizards program. The program is part of a long 3M tradition that provides teaching materials and training to employees for science outreach in schools, science fairs, and other public venues. The kit was designed to teach a few fundamental principles of classical optics through the history of the camera obscura. Camera obscuras have been used for centuries as a means of projecting an image of the real world onto a surface, usually a canvas, so that it may be copied or studied. The use of the device in the paintings of Vermeer and other painters (the "Hockney-Falco Thesis") is a hotly debated topic that is woven into the kit. As one of a few dozen kits created and used by 3M employees, this portable kit includes a collapsible black tent (the camera), a variable aperture and lens assembly (the pinhole and lens), an efficient collimated LED light source, and retroreflective garments, graphics, and eyeglasses. A laser pointer on a gimbal is used as an auxiliary part of the kit to teach the principle of image inversion in pinhole optics.

Session DG: PER: Evaluating Instructional Strategies I

Location: STSS 220
Sponsor: AAPT
Date: Tuesday, July 29
Time: 8–9:50 a.m.

Presider: Mila Kryjevskaia

DG01: 8-8:10 a.m. How Should We Teach Conceptual Understanding of Force and Motion?

Contributed – Daniel R. White, The Ohio State University, Columbus, OH 43210-1168; drwhite@mps.ohio-state.edu

Ryan C. Badeau, Andrew Heckler, The Ohio State University

We examine the effects of training examples on student responses to questions about the relationships between the directions of net force, velocity, and acceleration in one-dimension. Six training conditions were constructed, each dealing exclusively with one combination of net force, velocity, and acceleration (e.g., "given a velocity in this direction, what can you say about the acceleration"?) in a variety of contexts and added to a control condition (no training). While we find that acceleration-velocity and net force-velocity trainings led to the highest overall scores, we also find complex but robust interactions between training and test question types, consistent with hierarchies of student understanding of force and motion in previous works. Based on the empirical data we gathered, we build mathematical models of these hierarchies. We then use those models to predict which combinations of training are most effective, which is in turn suggestive of instructional strategies.

DG02: 8:10-8:20 a.m. Using a Natural Language Computer Tutor for Force and Motion

Contributed – Ryan C. Badeau, The Ohio State University, Department of Physics, Columbus, OH 43210-1168; ryan.badeau@gmail.com

Daniel R. White, Andrew F. Heckler, The Ohio State University

Force, velocity, and acceleration represent an interesting set of related physics concepts in that they are foundational, well-documented and a persistent source of student difficulty even after instruction. As such, this set of related concepts provides a unique conceptual space in which to explore the effects of different question formats and their role in targeting persistent student difficulties during computer-based training and instruction. By prompting students to respond to questions in natural language and subsequently providing immediate question specific feedback, we explore the potential benefit of natural language for targeting specific and persistent difficulties like the assumption of a force in the direction of motion. We report on the design and construction of a simple natural language computer tutor for concepts in one-dimensional force and motion and investigate the relative effectiveness of the natural language question and feedback format versus traditional multiple choice questions and responses.

DG03: 8:20-8:30 a.m. Effects of Computer Simulations on Learning in Undergraduate Physics

Contributed – Eric Marshall, U.S. Military Academy, West Point, NY 10996-5000; eric.marshall@usma.edu

Tyler Jones, U.S. Military Academy

Web-based computer simulations (sims) are widely used as teaching tools in the physics education community, though few controlled studies attest to if and how the sims actually contribute to learning. This paper describes a comprehensive experiment where several class sections of undergraduate students demonstrate highly significant achievement in mental model formation and long-term recall after working with sims. Four physics topics are targeted in a core undergraduate Physics I course at the U.S. Military Academy. Prominent student misconceptions in these topics are identified, and useful computer simulations for covering these topics are described in detail. The learning metrics of correct mental models and long-term recall are assessed quantitatively with a large control group, and qualitative student feedback is also provided. Possible causation of sims' success rate is explored and limitations of both this study, and sims' contribution to learning are noted.

DG04: 8:30-8:40 a.m. Learning Outcomes in a "Physics for Humanities Course"

Contributed – Deepak Iyer, Penn State University, University Park, PA 16802; deepaki@psu.edu

Mary Emenike, Rutgers University

We present the results of two surveys carried out on a "Physics for Humanities" class of about a hundred students. The Colorado Learning Attitudes about Science Survey (CLASS) is used to measure the shift in attitudes via a pre- and post-test carried out in the second installation of this class. Post-test data from the first installation of the course is also presented. The second survey is course specific and seeks to correlate aspects of the CLASS survey with student feedback about the pedagogical approaches used in the course. We seek to understand the efficacy of the various pedagogical tools used in achieving the learning goals. Further, the outcomes could potentially inform future versions of this class, and add to the data about physics courses for non-science majors.

DG05: 8:40-8:50 a.m. Nonscience Students Developing the Particle View of Ionizing Radiation*

Contributed – Andy P. Johnson, Black Hills State University, Spearfish, SD 57783; andy.johnson@bhsu.edu

Anna Hafele, Ryan Anderson, BHSU

The Inquiry into Radioactivity (IiR) project is developing course materials for radiation literacy. Student thinking about what constitutes ionizing radiation is a major learning difficulty. Most people use "radiation" and "radioactive" interchangeably, and talk of ionizing radiation as "bad stuff" that can transfer to other objects, making them radioactive. These matter-like ideas persist and interfere with the particle view. This paper reports on a longitudinal study of student thinking. Some students accepted the particle view after investigations with Geiger counters, but others did not adopt the particle view until grappling with atoms and with ionization by alpha, beta, and gamma particles. Thus we reluctantly conclude that brief or incomplete efforts to teach radiation to non-science learners will fail to incite the substantial ontological shift that is essential to understanding radiation as particles.

*This work is supported by National Science Foundation grant DUE 0942699.

DG06: 8:50-9 a.m. Exam Preparation Using Narrated Animated Solutions

Contributed – Noah Schroeder, University of Illinois, Urbana, IL 61801; schroe16@illinois.edu

Tim Stelzer, Gary Gladding, University of Illinois

Worked examples are common tools used to give students information about solution procedures, often as feedback after students fail to successfully complete a problem. Narrated animated problem solutions were created and implemented in several different contexts. Several clinical experiments were conducted to determine successful methods of implementation. Materials used were implemented using smartPhysics. Results will be shown.

DG07: 9-9:10 a.m. Mastery Learning in an Electromagnetism Course

Contributed– Brianne N. Gutmann, University of Illinois at Urbana-Champaign, Urbana, IL 61801; bgutman2@illinois.edu

Gary Gladding, Tim Steltzer, Noah Schroeder, University of Illinois at Urbana- Champaign

In an attempt to see the effect of mastery learning in physics, we created materials for an introductory electromagnetism course that tested superposition of electric fields, followed by electric potential, two subjects that have notoriously been difficult for our students. We presented these sets of questions in mastery mode, as a single presentation, or not at all, and compared performance on a written assessment. The effect of these tools, especially the mechanism for delivery (mastery or not), will be discussed and results will be shown.

DG08: 9:10-9:20 a.m. Design and Development of Targeted Mastery Exercises for Introductory Physics

Contributed – Gary Gladding, University of Illinois at Urbana-Champaign, Urbana, IL 61801; geg@illinois.edu

Tim Stelzer, Noah Schroeder, Brianne Gutmann, University of Illinois at Urbana-Champaign

We have developed and tested prototype online exercises targeted for specific learning objectives in introductory physics. These exercises are delivered in a "mastery" mode. That is, students are given a set of questions; if they do not answer correctly the minimum number required for mastery, they are given access to narrated animated solutions to these questions after which they are presented with a new set of questions. This process continues until the students achieve mastery. We will discuss the design of these questions and their solutions and present preliminary data on student learning from these exercises.

DG09: 9:20-9:30 a.m. Are We Reaching Limits of Practice Exam?

Contributed – Witat Fakcharoenphol, University of Illinois at Urbana-Champaign, Champaign, IL 61820; fakchar1@illinois.edu

Practice exams are commonly used by students to prepare for exams. Our first experiment showed that practice exams are useful but also limited (Fakcharoenphol 2011).[1] A series of experiments on practice exams was conducted to examine the effect of various feedback (Fakcharonephol 2014) and distributing practice exams throughout the semester. A followup experiment was conducted to understand the optimal conditions for helping students learn from practice exams.

W. Fakcharoenphol, E. Potter and T. Stelzer, "What students learn when studying physics practice exam problems," *Phys. Rev. ST Phys. Educ. Res*. **7**, 010107 (2011). W. Fakcharoenphol and T. Stelzer, "Physics exam preparation: A comparison of three methods," *Phys. Rev. ST Phys. Educ. Res.* (in process)

DG10: 9:30-9:40 a.m. Measuring the Effectiveness of Collaborative Group Exams

Contributed – Joss Ives, University of British Columbia, Vancouver, BC V6T 1Z1; joss@phas.ubc.ca

I will report on the results of a study designed to measure the effectiveness of an instructional strategy known as 2-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 featured different subsets of the questions from the individual exam. Questions isomorphic to the exam questions will be administered on the end-of-course diagnostic and comparisons, using the relevant isomorphic question, will be made between the students that saw a given question on the group exam and those that did not.

DG11: 9:40-9:50 a.m. Influence of Previous Subject Experience on Interactions During Peer Instruction

Contributed – Judy Vondruska, South Dakota State University, Brookings, SD 57007; judy.vondruska@sdstate.edu

In an analysis of correct/incorrect responses during peer instruction in an introductory survey of physics course for undergraduates, students with previous subject experience were found to have a higher correct response rate before and after discussion than all other partner groupings. If a student with previous subject experience was paired with a student with no previous subject experience, there was an increase in correct response rate after discussion but no lasting benefit was found on end-of-unit exams. If a discussion pair consisted of two students with no previous subject experience, correct response rates were low and remained low after discussion. The nature of the pairing appears to influence correct response rates to questions posed during peer instruction and also influences student's attitudes about the course and the value of peer instruction.

Session DH: Electronic Lab Notebooks

Location: Tate Lab 133
Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Educational Technologies
Date: Tuesday, July 29
Time: 8–9:10 a.m.

Presider: Ben Zwickl

DH01: 8-8:30 a.m. Electronic Lab Notebooks, Jet Packs, and Flying Cars

Invited – Edward Price, CSU San Marcos, 333 S. Twin Oaks Valley Road, San Marcos, CA 92096; eprice@csusm.edu

Electronic laboratory notebooks hold the promise of integrating computer-based data collection and analysis, written lab reports, digital archiving/sharing, and collaboration. Yet the reality often lags behind this promise. By adopting a broad perspective on educational technology, this talk will identify some of the conditions and features necessary for electronic lab notebooks to fulfill their promise and see wider usage. Lessons will be drawn from experience with TabletPC-based lab notebooks, photo-sharing websites, screencasts, and other educational uses of technology.

DH02: 8:30-8:40 a.m. Experiences with Lab Notebooks in Blackboard 9.1 – The Good, the Bad, and the Ugly

Contributed– David R. Klassen, Rowan University, Department Physics & Astronomy, Glassboro, NJ 08028; klassen@rowan.edu

Lab notebooks have been a mainstay in my introductory physics courses for quite some time now. In the spring of 2012 I transitioned from having each student keep their own physical notebook to each group of students keeping an online, electronic, notebook. This transition was done primarily to reduce waste and costs for students (having to buy lab notebook, half of which would go unused) and to reduce my burden (no more toting 24 notebooks to and from class and to and from home; scoring 1/3 as many notebooks). The secondary benefit was to introduce students to electronic means of keeping notes, including the use of modern online editor functions (equations, super- and subscripts, etc.). I will present here a summary of my experiences in having students use an online lab notebook platform; specifically, the use of BlackBoard 9.1 Wikis.

DH03: 8:40-8:50 a.m. Using LabArchives in Introductory and Advanced Physics Lab Courses

Contributed – John M. Caraher, DePauw University, Department of Physics & Astronomy, Greencastle, IN 46135-0037; johncaraher@depauw.edu

Electronic Lab Notebooks (ELNs) promise multiple practical and pedagogical advantages over traditional paper lab notebooks, but their adoption poses some unique challenges. I describe my own experience using one commercially available solution, LabArchives, as an ELN in two courses -- the lab for a calculus-based introductory mechanics course and the lab for an upper-level atomic and molecular physics course, both taught at a selective liberal arts college. Topics will include: ELN organization, ease of use for both students and instructor, archiving and sharing notebooks, student feedback on LabArchives ELN use, and methods for including equations, graphs, diagrams and other non-text elements in student ELNs.

DH04: 8:50-9 a.m. Using Student Screencasts for Assessment

Contributed – Andy Rundquist, Hamline University, St. Paul, MN 55104-1284; arundquist@hamline.edu

In an effort to capture some of the authenticity of oral exams in my normal assessments, I have used student screencasts to assess student understanding and application of concepts. I have also extended that to laboratory reports. I will present the strengths and weaknesses of the approach, focusing on how it helps me provide both tailored feedback and authentic evaluations. One feature for labs is the ability to assess individuals in a group, as their voice added to a common document helps to identify points that are well understood by each member.

Session DI: Arduinos Micro-Controllers and Underwater ROVs

Location: Tate Lab 133
Sponsor: Committee on Physics in Two-Year Colleges
Date: Tuesday, July 29
Time: 9:20–10 a.m.

Presider: Tom Carter

DI01: 9:20-9:30 a.m. Arduino Uno Microcontrollers Measuring Thermal Effects During Stratospheric Balloon Flights

Contributed – Erick Agrimson, St. Catherine University, St. Paul, MN 55105; epagrimson@stkate.edu

Rachel DuBose, Kaye Smith, St. Catherine University

James Flaten, Spencer McDonald, University of Minnesota

We present results from a study of the thermal wake that trails below ascending high-altitude balloons (weather balloons) on flights into the stratosphere, sometimes called "near space." Data is collected using horizontal 1-D and 2-D arrays of temperature sensors hanging below the balloon in the thermal wake and logged using Arduino Uno microcontrollers. We characterize the physical width and thermal profile of the wake, which is warmer than the surrounding air during day-time flights, due to solar heating of the balloon, and colder than ambient air during night-time ascents. Temperatures drop to well below -50 degrees Celsius during a typical high-altitude flight as the apparatus ascends through the tropopause. We also evaluate the performance of digital DS18B20 temperature sensors and Arduino Uno microcontrollers in the near-space environment.

DI02: 9:30-9:40 a.m. Arduino in an Undergraduate Lab Curriculum and Applications

Contributed – Tia V. Troy, Winona State University, Minneapolis, MN 5541;7 tvtroy@live.com*

Nathan Moore, Megan Reiner, Andrew Haugen. Winona State University

Throughout the spring semester 2013 at Winona State University, a new curriculum was implemented in the Physics 221 Labs. The new curriculum was motivated by previous attempts to introduce the Arduino Microcontroller into the curriculum. Most of the evidence about this project's success is anecdotal and is based on integration of technology and on the development of the students' ability to use technology in the classroom. During integration, one lab was selected for further research. The lab selected was a setup that could be modeled as an oscillating spring system and the frequency of small oscillations can be found using energy conservation. From data collected with various sensors, including the Arduino distance sensor, a paper is being developed.

Sponsored by Dr. Nathan Moore

DI03: 9:40-9:50 a.m. Research on Productive Tinkering in an Arduino Environment

Contributed – Gina M. Quan, University of Maryland, College Park, MD 20742; gina.m.quan@gmail.com

Ayush Gupta, University of Maryland

In the engineering design process as taught in middle/high school classrooms, systematic planning is often valued over tinkering, a process that shortcuts that kind of analytical thinking. We argue that tinkering could be productive for students' learning. We piloted a project-based instructional module using Arduino Rovers (Arduino integrated programmable robot-tanks) in Summer Girls, a summer camp for high school students hosted by University of Maryland Physics Department. Throughout the two-week program, participants worked in pairs through several open-ended tasks before designing and completing a final project. Using classroom video data of student-pairs working on the design tasks, we contrast ad-hoc tinkering with planned, deliberate sense-making. We argue that tinkering is a productive practice for project-based learning, contributing to practical success on task and supporting students in learning content. We suggest that instructors of design tasks should consider ways to recognize students' tinkering practices and support them in tinkering productively.

DI04: 9:50-10 a.m. Adapting Modeling Instruction to DIY Arduino (Microcontroller) Lab Equipment Development

Contributed – Nathan T. Moore, Winona State University, Winona, MN 55987-0838; nmoore@winona.edu

Andrew Haugen Winona State University

The Arduino Microcontroller is an inexpensive, easy to program board that introductory students can use to create simple data acquisition equipment. However, standard training in microcontroller programming takes the form of either endless streams of dubious quality Youtube videos, or dense EE books on assembly language programming. Obviously, neither of these options is appropriate for the introductory University Physics Lab. In the work, I will describe how Modeling Instruction can be adapted to provide a conceptual and curricular framework for introducing microcontroller DAQ programming into the intro lab. Briefly, the process can be thought of as Model development (calibration, signal conditioning, algorithms), and Model deployment (physical analogs to context-rich group problems). Results from two implementations of this approach to the introductory lab, using both Arduino/C and Labview programming environments, will be discussed.

Session DJ: Reform Dissemination: Successful Examples

Location: Tate Lab 131
Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 29
Time: 8–9:10 a.m.

Presider: Vince Kuo

DJ01: 8-8:30 a.m. A Widely Disseminated, Discipline Crossing, Radical Reform: The SCALE-UP Story*

Invited – Melissa Dancy, University of Colorado - Boulder, Department of Physics, Boulder, CO 80309-0001; melissa.dancy@gmail.com

Katie Foote, Robert Beichner, NC State University

Charles Henderson, Xaver Neumeyer, Western Michigan University

Scale-Up is a radical reform geared toward high levels of student engagement utilizing integrated lab-lecture in a redesigned room. The first Scale-Up course was taught in 1997. Since then Scale-Up as spread widely across many institutions and disciplines. A recent survey identified 314 departments at 189 institutions in 21 countries that report being influenced by or using some version of SCALE-UP style instruction. Departments represented many distinct disciplines. We are in the process of studying the dissemination of SCALE-UP though a social network analysis, surveys, interviews, and site visits. Research questions include: How has knowledge about SCALE-UP spread? What leads a department to consider, adopt, modify or abandon SCALE-UP? How does the method of learning about SCALE-UP and departmental factors impact how SCALE-UP is implemented? In this talk we report on findings to date from this project.

*Supported by NSF, #1223405, #1223564, and #1223405

DJ02: 8:30-8:40 a.m. "SCALE-UP" at the University of Michigan-Flint

Contributed – Christopher Pearson, University of Michigan-Flint, 303 E Kearsley St., Flint, MI 48502; pear@umflint.edu

Inspired in part by the work of Beichner et. al. (http://www.ncsu.edu/per/scaleup.html), the introductory physics course environment at the University of Michigan-Flint has transformed from a typical arrangement of large-lecture/small-lab to an integrated lecture-lab environment. Necessary infrastructure changes were made possible through a generous gift from a physics alumnus and the David Zick Active Learning Classroom was created. An overview of the learning environment will be presented as well as observations gleaned from the initial use. A comparison of scores from the Force Concept Inventory and the Conceptual Survey of Electricity and Magnetism before and after the creation of the classroom are used to assess changes in student learning due to the change in learning environment. Student retention and student comments as well as faculty load and staffing changes will also be discussed.

DJ03: 8:40-8:50 a.m. SCALE-UP, Scaled Down

Contributed – Brandon R. Lunk, Elon University, Carrboro, NC 27510; brlunk@ncsu.edu

The Student Centered Active Learning Environment using Upside-down Pedagogies (SCALE-UP) project was designed to promote a style of classroom environment that brings the intimacy of small, discussion-based seminars and laboratories to large enrollment courses. Although the most recognizable characteristic of a SCALE-UP classroom is the architecture —specifically the multiple large, round tables situated within a large capacity studio —the SCALE-UP philosophy is meant to function more as a framework for establishing and maintaining interactive pedagogies. Thus even the small classes typical of many liberal arts and community colleges can be taught using SCALE-UP. In this talk, I will discuss my use of the SCALE-UP framework within small, 24 person introductory physics courses at Elon University.

DJ04: 8:50-9 a.m. Studying the Spread of Research-based Instructional Strategies: Rich Case Study of SCALE-UP

Contributed – Kathleen T. Foote, North Carolina State University, Raleigh, NC 27606; ktfoote@ncsu.edu

Xaver Neumeyer, Charles Henderson, Western Michigan University

Melissa Dancy, University of Colorado, Boulder

Robert Beichner, North Carolina State University

Much time, money, and effort has been spent developing innovative teaching pedagogies. But, the majority of college instruction in physics fields is inconsistent with research-based recommendations. This project investigates the dissemination and implementation of research-based instruction by using a web survey to understand the spread of SCALE-UP (Student-Centered Active Learning Environment with Upside-down Pedagogies). Responses from 659 people indicate that SCALE-UP is used at over 250 institutions worldwide and has also spread to disciplines beyond physics. Information about SCALE-UP has traveled through both formal and informal channels. Secondary sites frequently modify the original SCALE-UP model, which may impact the success of the implementation. According to the Diffusion of Innovations theory, the developer may need to change the message to continue increasing the number of sites beyond early adopters.

DJ05: 9-9:10 a.m. Transitioning Introductory Physics at UNC Chapel Hill

Contributed – Alice D. Churukian, University of North Carolina at Chapel Hill, Department of Physics & Astronomy, Chapel Hill, NC 27517; adchuruk@physics.unc.edu

Duane L. Deardorff, University of North Carolina at Chapel Hill

At the University of North Carolina at Chapel Hill we have been teaching one reformed section of calculus-based introductory physics using the SCALE-UP (Student Centered Active Learning Environment for Upside-down Pedagogies) methodology since fall 2010. While the pilot study proved successful, we were unable to take the next step of "scaling up" to use this approach for all students. Beginning fall 2013 we adopted a Lecture/Studio methodology—a hybrid of traditional and interactive engagement—for all students. In this approach, students have one hour of lecture and two hours of studio twice per week. In this fashion we were able to offer large lecture sections for efficiency, but retain smaller, more intimate studios for hands-on, minds-on problem-solving and laboratory activities. How we got to where we are today, and the lessons learned along the way, will be discussed.

Session DK: If They Build It, They Will Learn

Location: Tate Lab 131
Sponsor: Committee on Physics in Pre-High School Education
Date: Tuesday, July 29
Time: 9:20–10 a.m.

Presider: Bill Reitz

DK01: 9:20-9:30 a.m. Build a Submarine Lab: Buoyancy, Density, Volume, and Pressure

Contributed – Lori Nesbitt, J.I. Case High School, Racine, WI 53406; lori.nesbitt@rusd.org

This class is about underwater exploration. We will play with the concepts of buoyancy, density, volume, and pressure enabling us to explore a body of water at varying depths. It will be your job to figure out how to use these concepts to dive and retrieve objects while being fully in control! Your first challenge is to design a set of simple devices that house instruments to take water samples for the Water Quality Monitoring Project. You need to collect samples at the surface, middle and bottom of the body of water. You need to design three instruments, each varying in density, so one will float, one will hover, and one will sink. Your second challenge is to design

Ceremonial Session: AAPT Klopsteg Memorial Lecture Award Presented to Donald W. Olson

Location: Northrop Auditorium
Date: Tuesday, July 29
Time: 10:30–11:30 a.m.

Presider: Gay Stewart

Don Olson

Celestial Sleuth: Using Physics and Astronomy to Solve Mysteries in Art, History, and Literature

Donald W. Olson, Texas State University, San Marcos

How do astronomical methods make it possible to identify celestial objects and to calculate dates and times for night-sky paintings by Vincent van Gogh and J. M. W. Turner? When did Claude Monet witness a dramatic sunset on the Normandy coast? Why is there a blood-red sky in Edvard Munch's "The Scream"? On what dates did Ansel Adams create his moonrise photographs in Yosemite? What spectacular celestial event inspired Walt Whitman to write a poem and Frederic Church to create a painting? Why is a bright star described in Act 1, Scene 1, of *Hamlet*? On what date did the Roman fleet commanded by Julius Caesar invade Britain? To answer questions like these, faculty and students from Texas State University have made research trips to the relevant sites and have published a series of articles over the last two decades, applying physics and astronomy to art, history, and literature.

and create a vessel that can become negatively buoyant, retrieve an object at the bottom, then become positively buoyant to bring the object back to the surface.
*Sponsored by Melissa Vigil

DK02: 9:30-9:40 a.m. There's More to the Story: Activities to Accompany Middle School Literature

Contributed – William E. Reitz, 2921 Kent Rd., Silver Lake, OH 44224; wreitz@neo.rr.com

Try several make n takes that flow from popular MS fiction, nonfiction and graphic novels. Materials and references provided.

DK03: 9:40-9:50 a.m. Sound and Music on the Cheap

Contributed – Wendy K. Adams, Department of Physics and Astronomy, Greeley, CO 80631; wendy.adams@unco.edu

Several hands-on sound and music activities for ages 4-100 will be presented. Materials and instructions will be provided to assemble your own straw trombone and cup banjo. Other acoustic demonstrations will be presented including tuning fork transfer of energy to Ping-Pong balls and water and resonance with pasta and raisins.

DK04: 9:50-10 a.m. Sparking Student Interest: E&M Activities for Middle School and Beyond

Contributed – Anne J. Cox, Eckerd College, St. Petersburg, FL 33711; coxaj@eckerd.edu

Students build a stylus for an i-device/smartphone, simple motor and other devices in activities inspired by a DIY ("Do-It-Yourself") or "Maker" philosophy. The idea is for students to learn as they build their own experiments or demonstrations. These activities have been used successfully with middle school as well as introductory college students.

The Easy JavaScript Simulations Platform: A Reader for Android and iOS Tablets, A Simple Authoring Tool to Create Simulations, and the ComPADRE OSP Library

Location: STSS 420A
Date: Tuesday, July 29
Time: 12–1 p.m.

The Easy Java/JavaScript Simulation (EjsS) program enables students and teachers to create simulations by providing a set of simplified tools to lower the barrier to programming. To date over 500 Java simulations for astronomy and physics have been created with EjsS and are available on the ComPADRE Open Source Physics (OSP) Collection. Recently, the functionality of EjsS has expanded to include the creation of JavaScript simulations that run on computers and tablets. This workshop introduces the EjsS tool (freely available on ComPADRE) to participants and leads participants through creating simple JavaScript simulations. Participants will receive the free EjsS Reader for tablets to quickly and easily download and run JavaScript simulations from ComPADRE. Participants are encouraged to bring laptops to install and run the EJS authoring tool and tablets to install the Reader. < http://www.compadre.org/OSP/> and < http://fem.um.es/Ejs/>.

Session EA: Panel – Bridging Research and Teaching through Computation

Location: STSS 330
Sponsor: Committee on Educational Technologies
Date: Tuesday, July 29
Time: 1–3 p.m.

Presider: Jan Tobochnik

Presenters will describe their research using computation and how it can enrich the undergraduate curriculum.

EA01: 1-1:30 p.m. Using Computation to Teach the Physics of Phase Transitions

Panel – Robert H. Swendsen, Carnegie Mellon University, Pittsburgh, PA 15213; swendsen@cmu.edu

The van der Waals model of a fluid has been an essential part of courses in thermodynamics since it was first proposed in 1873. It is relatively simple, but still gives a remarkably good description of the properties of real gases. On the other hand, the analytic solution of the van der Waals equations is non-trivial, which has led to the neglect of much of its richness. In this talk, I'll discuss how simple numerical methods can be used to generate graphs of the compressibility, the coefficient of thermal expansion, and the specific heat at constant pressure, all of which exhibit divergences at the critical point. The behavior of these quantities and others at first-order phase transitions turns out to be especially interesting. Numerical methods give rise to new insights into the van der Walls model that can greatly improve students' understanding and appreciation of the physics of phase transitions.

EA02: 1:30-2 p.m. Still Water: Dead Zones and Liquid-like Flow from Granular Impact

Panel – Wendy W. Zhang, University of Chicago, The Physics Department and the James Franck Institute, Chicago, IL 60637; wzhang@uchicago.edu

The impact of two colliding objects is the rudimentary process that underlies splashing and coalescence at the human-size scale, as well as cratering and even planet formation on the celestial scale. Impact leads to catastrophic deformation as the incoming objects distort and change shape. Impact has also been used to create the quark-gluon plasma, the primordial constituents of the universe, in high-energy collisions in accelerators. Nonetheless, the seemingly complicated physics of impact can sometimes lead to elegant results that can be understood simply. I will describe our studies on the impact of granular jets composed of densely packed macroscopic grains. Impact onto a fixed target yields liquid-like ejecta flow whose structure is controlled by dissipationless perfect fluid flow, despite the fact that the impact process itself is highly dissipative. In contrast, the collision of two jets can produce an impact region that drifts steadily over time, with larger drift speeds produced by grains with larger coefficients of friction. Joint work with Jake Ellowitz, Herve Turlier, Nicholas Guttenberg and Sidney R. Nagel.

EA03: 2-2:30 p.m. Teaching Statistical Physics with Python

Panel – Leonard M. Sander, University of Michigan, Physics, Ann Arbor, MI 48109-1040; lsander@umich.edu

I will outline my experience in teaching statistical physics at the graduate level using computer simulations in Python. This course uses the author's recent textbook, Equilibrium Statistical Physics, (Createspace, 2013). The book is based a point of view that the best way to learn this subject is to do hands-on computer simulations as part of learning the subject. Almost everyone who teaches physics courses knows that statistical physics seems peculiarly difficult to learn. The pioneers of this subject possessed a powerful imagination which allowed them to visualize chaotic, many-particle processes and understand their nature: this is the essential difficulty. Lesser mortals are enormously aided by using simulations to guide learning. In fact, I think that the easiest way to really grasp what is meant by entropy, irreversibility, and thermal equilibrium is to watch small many-particle systems develop in a concrete way, as I will demonstrate in the talk.

Session EB: Physics in a Biological Context II

Location: STSS 312
Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 29
Time: 1–2:20 p.m.

Presider: Nancy Beverly

EB01: 1-1:10 p.m. Analyzing NEXUS/Physics Laboratory Curriculum in a Large-enrollment Environment

Contributed – Kimberly A. Moore, University of Maryland, College Park, MD 20742; MoorePhysics@gmail.com

Wolfgang Losert, John Giannini, University of Maryland, College Park

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 2013-2014. These labs address physical issues at biological scales using microscopy, image, and video analysis, electrophoresis, and spectroscopy in an open, non-protocol-driven environment. We have collected a wealth of data (surveys, video analysis, etc.) that enables us to get a sense of the students' responses to this curriculum in a large-enrollment environment and with teaching assistants "new" to the labs. In this talk, we will provide a brief overview of what we have learned and a comparison of our large-enrollment results to the results from our pilot study. Additionally, we will share data examining the change in self-reported student goals, which we believe is an indication of our lab curriculum's impact on student thinking. (This work is supported by funding from HHMI and the NSF.)

EB02: 1:10-1:20 p.m. Physics for the Life Sciences with the MCAT In Mind

Contributed – Michael G. Cherney, Creighton University, Omaha, NE 68178; mcherney@creighton.edu

A new algebra-based General Physics option will be available to Creighton University students this fall. These courses are intended for life science majors. The conceptual reasoning, the attention to medical and biological applications of physics, the mental math skills and the new emphasis on research skills and methods that will be promoted in the 2015 MCAT are informing the development of the new syllabuses. This new General Physics offering divides the traditional first-semester college physics topics (including fluids and basic material properties) as well as rudimentary statistical analysis between a three-credit lecture course and a one-credit laboratory course.

EB03: 1:20-1:30 p.m. Physics for the Life Sciences After the Introductory Sequence

Contributed – Al J. Adams, University of Arkansas at Little Rock, Little Rock, AR 72204-1099; ajadams@ualr.edu

I have designed and now taught a one-semester 3000-level physics course entitled "Intermediate Physics for the Life Sciences." The course was populated by both upper-level physics majors and students in biology with interest in professional schools in health care or biomedical research. The course is designed to 1) allow students with a recent introductory sequence experience the opportunity to apply the principles to systems of immediate interest to them, 2) explore many of the traditionally neglected topics in the introductory sequence that are of importance in biology, 3) explore some of the important ideas through laboratory measurements, and 4) allow students who will take the MCAT a chance to prepare for the physical science component. I will overview the curriculum and the pedagogical approaches taken in this first rendering, and then present assessment results for this first (spring 2014) offering.

EB04: 1:30-1:40 p.m. Physics Active Learning (PAL) Problems in a Biological Context

Contributed – Nathan H. Frank, Augustana College, Rock Island, IL 61201-2296; nathanfrank@augustana.edu

Engaging students from biology or health pre-professional programs in introductory physics courses presents a unique challenge. One way to increase student engagement is to design physics active learning (PAL) problems that show the connection between physics and biology. Often the biology is more complicated than can be accommodated in an algebra-based course, but simple models and demos can elucidate the physics of biological systems. This talk will show several examples of these types of problems such as the ATP Synthase molecule for rotational motion, virus springs, and the human body. Strategies for finding biology contexts and initial survey data showing positive student attitudes will also be presented.

EB05: 1:40-1:50 p.m. A New, Ready-to-Use Axon Lab

Contributed – Joshua M. Dyer, Augustana College, Rock Island, IL 61201; JoshuaDyer@augustana.edu

I have created a new physics lab that illustrates physics within the human body. This lab demonstrates the dimensional aspects of resistance and teaches principles of resistivity (and conductivity) and circuitry. The lab also connects these physics concepts to biology curricula with axons and electrical impulse in animals. Furthermore, it demonstrates the physical cause of multiple sclerosis and asks students to examine ways that nature might solve this problem through evolution. This presentation will outline the design, procedure, and student analysis of this lab which is simple in construction and can easily be added to any curriculum.

EB06: 1:50-2 p.m. Two Examples on How to Make AC Circuits Relevant to Pre-health and Life Science Students

Contributed – Ralf Widenhorn, Portland State University, SRTC, Portland, OR 97201; ralfw@pdx.edu

Elliot Mylott, Justin Dunlap, Ellynne Kutschera, Portland State University

AC circuits are included in all standard introductory general physics textbooks. However, while engineers taking this course may easily see the relevance to their field, life science and pre-health students often struggle to see how AC circuits are relevant to their future study. We will present two lab activities that teach AC circuits in a biomedically relevant context. A circuit lab on the electrocardiogram (EKG) shows how an EKG sensor acts as a band pass filter and removes high and low frequency signals. Students then observe how a RLC circuit can be used to build a simple band pass filter. A second lab on biomedical impedance analysis (BIA) explores the concepts of AC currents, AC voltages, phase shifts, phasor diagrams, and impedance measurements. In this lab students can calculate a person's body composition using measurements of impedance and phase angle from a small current injected into the human body. They can compare these results to measurements of RC circuits that model the resistive and capacitive characteristics of the human body.

EB07: 2-2:10 p.m. Syllabus for Pre-medicine Physics

Contributed – Donald G. Franklin, Spelman College/Mercer University, Hampton, GA 30228; dgfrank1@aol.com

Using OpenStax Physics you can design your course so your students will realize that physics is important for the pre-med candidate. Start with Chapter 32-Medical Applications of Nuclear Physics. Then Chapter 31-Radioactivity and Nuclear Physics. Then Chapter 30-Atomic Physics. Now you have your student's attention and can teach how Classical Physics is used to prepare pre-medicine majors!

EB08: 2:10-2:20 p.m. Designing a New IPLS Course: Goals, Challenges and Early Evaluation*

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, Laurie E. McNeil, University of North Carolina at Chapel Hill

At the University of North Carolina at Chapel Hill, we have embarked on a mission to redesign our introductory physics course for life science majors. Taking recommendations from recently published national reports and the research of others, our team has set out to develop a course that better suits the needs of the student population. Early development has included significant discourse with faculty from the biology department, with emphasis placed on identifying critical cross-disciplinary skills and authentic biological contexts. We will discuss the goals and objectives of this new course and the challenges faced during the initial stages of development. In addition, we will outline the early evaluation of our curricular materials as a result of their implementation during the first summer session at UNC-CH.

*This work has been supported in part by the National Science Foundation under Grant No. DUE-1323008.

Session EC: Teachers in Residence

Location: STSS 412
Sponsor: Committee on Teacher Preparation
Date: Tuesday, July 29
Time: 1–2:40 p.m.

Presider: Jon Anderson

EC01: 1-1:30 p.m. Using and Sustaining the Teacher-in-Residence: A Ten-year Report

Invited – Chance Hoellwarth, Cal Poly San Luis Obispo, Physics Department, San Luis Obispo, CA 93407; choellwa@calpoly.edu

The Science Teacher-in-Residence (TIR) has played an important role in producing more physics teachers at Cal Poly. The TIR position has been continuously supported for the past 11 years. Initially the position was made possible by a grant from PhysTEC, but the dean of the College of Science and Mathematics has continued to support the position. Over the 11 years there have been four different TIRs, and on more than one occasion there have been two TIRs on campus together. They have taught reformed courses, introduction to science teaching courses for potential teachers, as well as methods and education courses for credential candidates. They have supervised student teachers, built relationships with local teachers and the School of Education. This talk will discuss the impact the TIR has had on recruitment of more science teachers, the different roles they have played over time, and how the position has been internally sustained.

EC02: 1:30-2 p.m. TIRs Working Outside the Box

Invited – Alma Robinson, Virginia Tech, Department of Physics, Blacksburg, VA 24061; almaphotos@hotmail.com

Virginia Tech's PhysTEC program has just completed its third and final year of PhysTEC funding and the outlook for sustaining our PhysTEC program is promising. We have started a Learning Assistant program, developed a Physics Teaching and Learning course, expanded our outreach program, created stronger ties to the School of Education, and reformed some of our introductory physics courses to be more student-centered. In addition to discussing the role and responsibilities of the Teacher in Residence within these programs, this talk will also focus on the unique situation given to our TIR as an instructor in the Physics Department, a member of the undergraduate committee, and the adviser of our SPS. Through these avenues, the TIR is able to seamlessly incorporate the goals of PhysTEC throughout the physics department and increase awareness of PhysTEC programs to both students and faculty.

EC03: 2-2:10 p.m. Matching Our Efforts to Their Needs: Year One TIR Reflections

Contributed – Kevin Thomas, University of Central Florida, Orlando, FL 32816; kevin.thomas@ucf.edu

The University of Central Florida (UCF) recently became a PhysTEC comprehensive site, which has enabled us to develop and expand several programs to support high school physics teaching. The PhysTEC teacher-in-residence (TIR) has been instrumental in expanding our existing Learning Assistant (LA) and outreach programs, as well as adding an in-service Teacher Advisory Group (TAG) and encouraging a community in which these efforts can flourish. This talk will highlight the results of an online survey that allowed us to better understand the needs of the local high school physics teaching community and how those results have informed our efforts to engage with that community. Specifically, the UCF TIR will discuss how the results have shaped his interactions with the TAG and local school districts and led to outreach opportunities for LAs in local physics classrooms.

EC04: 2:10-2:20 p.m. Second Year PhysTEC Program at Alabama: An Update

Contributed – Penni H. Wallace, University of Alabama, Tuscaloosa, AL 35487; pahwallace@comcast.net

The University of Alabama, in its second year of a PhysTEC grant, continues to actively recruit physics majors to consider teaching as a career. In the fall, Alabama was also awarded a NOYCE grant in order to increase the number of math, chemistry, and physics teachers. This award, combined with a large pre-existing large NSF-MSP award provides scholarships to recruit and support pre-service physics teachers. In this talk, the second-year Teacher-in-Residence will discuss how the presence of two large NSF grants are being used to recruit students to the physics education track and provide an update on the program from the first to the second year.

EC05: 2:20-02:30 p.m. TIR Roles & Possibilities

Contributed – John M. Rowe, University of Cincinnati, Cincinnati, OH 45236; rowej@ucmail.uc.edu

The presenter will discuss the many possibilities that a TIR position brings to a university. There will also be be a "check the boxes" list of things to consider when deciding to implement a TIR position.

EC06: 2:30-2:40 p.m. The Part-time TIR and Classroom Teacher

Contributed – Elizabeth Walker, Georgia State University, Atlanta, GA 30303; elizabeth.walker@cobbk12.org

The Department of Physics & Astronomy at Georgia State University has begun an effort to increase the quantity and quality of high school physics teachers with an emphasis on increasing recruitment into teaching of students from under-represented groups. GSU is a large, growing, urban, research university with a diverse student body. As a new PhysTEC comprehensive site, our efforts include new recruiting, mentoring, and induction strategies, reform of introductory, calculus-based physics courses, and the addition of a teacher-in-residence (TIRs). TIRs are professionals in both physics and education, making them perfectly positioned to bridge the gap between the two often separate worlds. Ideally the TIR is available full time to assist with the sustained development of the physics education program. As a current classroom teacher and part time TIR, I will discuss challenges encountered during our first year of PhysTEC at Georgia State University.

Session ED: PER: Diverse Investigations

Location: STSS 220
Sponsor: AAPT
Date: Tuesday, July 29
Time: 1–3 p.m.

Presider: Beth Lindsey

ED01: 1-1:10 p.m. Effect of Prior Belief on Data Inference

Contributed – Abigail M. Bogdan, The Ohio State University, Columbus, OH 43210-1168; bogdan.22@osu.edu

Andrew F. Heckler, The Ohio State University

This study builds on past research that explored the effect of prior belief on students' ability to draw inferences. Results, indicating an effect of prior belief, are replicated and compared with statistical reasoning ability. 600 students in a calculus-based mechanics course participated in one of two conditions. In the first condition, data tables were presented within a physical context and students were given a short pre-test measuring their beliefs about the context. In the second, the tables were given within a generic context. Compared to students given the generic context, students given the physical context drew valid conclusions more frequently when the data aligned with their prior beliefs but less frequently when the data conflicted with their beliefs. Additionally, 270 students were given the Berlin Numeracy Test to evaluate their statistical numeracy. While results from previous studies have disagreed, in this case, students' numeracy was positively correlated with their correctness.

ED02: 1:10-1:20 p.m. Understanding Student Evaluations of Others' Problem Solving

Canceled

Contributed – Anna Kiefte, Acadia University, Deptartment of Physics, Wolfville, NS B4P 2R6 Canada; anna.kiefte@acadiau.ca

Geoff Potvin, Florida International University

Prior work has shown that students show a bias against female physics teachers by the beginning of college, are aware of and respond to societal stereotypes about their performance, and faculty have been found to exhibit evaluative biases against female students. However, the effects of bias between peers has not been studied well, even though it may have a significant effect on affective experiences and physics learning. To address this gap, in this preliminary study students were presented with different solutions to a typical introductory problem purportedly written by other pseudonymous students. They were asked to score the solutions (and provide justification) as well as predict the course grade the "solver" would receive. We analyze the data for gender bias in two ways: via the gender of the purported solver, and that of the assessor. We also examine students' justifications to understand their perceptions of problem-solving approaches.

ED03: 1:20-1:30 p.m. Peer Evaluations vs. Instructor Evaluations of Student Lab Reports

Contributed – Shih-Yin Lin, Georgia Institute of Technology, Atlanta, GA 30332-0002; hellosilpn@gmail.com

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

As part of an introductory physics course offered at Georgia Tech, students submit video reports on force and motion labs. Peer grading of reports provides the primary method for evaluating student laboratory work. During peer grading, students are guided to rate each others' videos on a rubric consisting of several likert-scale questions. They are also encouraged to provide written feedback explaining their grading for each rubric item. This paper explores how peer evaluations compare to instructors' evaluations by examining the likert-scale responses and written responses provide by both students and instructors. The written responses will be coded to understand what students and instructors attend to in their grading. Similarities and differences between student grading and expert grading will be discussed.

ED04: 1:30-1:40 p.m. Comparing Paper-based and Computer-based Testing

Contributed – Krista M. Kecskemety, he Ohio State University, Engineering Education Innovation Center, T Columbus, OH 43210; kecskemety.1@osu.edu

Meagan Ita, Kathleen A. Harper, Engineering Education Innovation Center, The Ohio State University

Brooke C. Morin

Advancements in technology have made electronic administration and grading of exams more prevalent. The staff of the Fundamentals of Engineering for Honors program at The Ohio State University recently began delivering a portion of each midterm and final exam via the university's online course management system. To assess whether changing to this style impacted student performance, a study was conducted to compare the two formats. For each exam in an introductory programming course, the computer-administered part of the test was split into an A half and a B half. Half of the students took part A on the computer and part B on paper, and vice/versa for the other half of the students. Additionally, students were asked a question about whether they had a preference for one format over the other. Results will be discussed, along with implications for the structure of future exams.

ED05: 1:40-1:50 p.m. Analysis of LA Program Impact through Community of Practice Theory

Contributed – Eleanor W. Close, Texas State University, Department of Physics, San Marcos, TX 78666-4615; eclose@txstate.edu

Jessica Conn, Hunter G. Close, David Donnelly, Texas State University

We are studying in how participation in the Learning Assistant program at Texas State University influences LAs' identity as physics students and physics teachers; in particular, how being part of the LA community changes participants' self-concepts and their day-to-day practice. Our analysis of self-concepts is informed by the identity framework developed by Hazari et al.,[1,2] and our analysis of practice is informed by Lave and Wenger's theory of Communities of Practice, [3, 4] We have developed a blended theory in order to analyze and explain LA program impact. We find that LAs expand their repertoire both of what they know how to do and of what they see as valuable in physics, consistent with Wenger's characterization of identity as community membership; and that recognition by faculty and peers supports LAs' continuing engagement, consistent with Wenger's characterization of identity as negotiated experience. We provide examples from our data.

1 Hazari et al., *JRST* **47**(8), 2010.
2.Lock, Hazari, & Potvin, in *AIP Conf. Proceedings* 1513, 2013.
3. J. Lave & E. Wenger, 1991.
4. E. Wenger, 1998. Research supported by NSF grant DUE-1240036.

ED06: 1:50-2 p.m. Developing an Identity of Competence Through the Learning Assistant Program*

Contributed – Jessica Conn, Texas State University, San Marcos, TX 78666-4615; jmc225@txstate.edu

Eleanor W. Close, Hunter G. Close, David Donnelly, Texas State University

The physics department at Texas State University has implemented a Learning Assistant (LA) program with reform-based instructional changes in our introductory course sequences. We are interested in how participation in the program influences LAs' identity both as physics students and as physics teachers; in particular, how being part of the LA community changes participants' self-concepts and their day-to-day practice. We analyze written artifacts from program applications, reflections, evaluations, and group activities, as well as video of interviews with returning LAs. Our analysis suggests that engagement in the LA program increases LAs' sense of competence both in physics content and in the practice of engaging in the physics community. LAs change their perceptions of what constitutes competence: they learn to value and enjoy the practice of interactive, logical exploration and argumentation, which re-purposes being wrong (or saying wrong things) from a form of incompetence to an important component of competent engagement.

*Research supported by NSF grant DUE-1240036

ED07: 2-2:10 p.m. Exploring One Aspect of Pedagogical Content Knowledge of Teaching Assistants Using the Test of Understanding Graphs in Kinematics*

Contributed – Alexandru Maries, University of Pittsburgh, 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. In particular, for each item on the TUG-K, the graduate students were asked to identify which incorrect answer choice they thought would be most commonly selected by introductory physics students if they did not know the correct answer after instruction in relevant concepts. We used the graduate student 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

ED08: 2:10-2:20 p.m. Assessing Future Elementary Teachers' Pedagogical Content Knowledge*

Contributed – Claudia Fracchiolla, Kansas State University, Manhattan, KS 66506; fracchiollac@ksu.edu

N. Sanjay Rebello Kansas State University

Pedagogical Content Knowledge (PCK) is an important aspect in the preparation of future teachers. The Concepts of Physics (CoP) course at Kansas State University has been recently redesigned to infuse PCK for pre-service elementary teachers. CoP integrates the learning of physics concepts with children's ideas about those concepts. The course is structured around the pedagogical learning bicycle, which bridges the learning of content with pedagogy through metacognitive reflection. As a final class project, students are required to work in groups to develop a lesson plan on one of the topics taught during the semester. In this talk I describe how we assess the impact of the class on students' PCK. We evaluated their projects based on how they incorporated their understanding of children's ideas on the specific topic to develop age-appropriate strategies to facilitate children's learning of these concepts. This material is based upon work supported by the National Science Foundation under grant 1140855.

*This material is based upon work supported by the National Science Foundation under grant 1140855.

ED09: 2:20-2:30 p.m. A Meta-cognitive Approach for Professional Development of Experienced Physics Teachers

Contributed – Osnat Eldar, Oranim Academic College of Education, 25 Lotem st. Timrat, 36576 Israel; eldar@oranim.ac.il

Shirley Miedjensky, Oranim Academic College of Education

We focus on the design and study of a meta-cognitve approach to the professional development (PD) of high school physics teachers. We designed and study a courses that is a part of a two-year M.Ed. program designed for experienced high school science teachers. The teachers were asked to develop teaching units in physics and were given the opportunity to teach and apply their units to children participating in an enrichment program in the college. The goals of our study were to characterize the design principles of the teaching units and to examine the changes in the design that followed the interactions between the participants in order to understand the teachers' meta-cognitive knowledge about designing teaching units in physics. The data included: interviews with the teachers; reflections of the researchers; the teachers' teaching units and activities; and observations of the teachers' physics lessons.

ED10: 2:30-2:40 p.m. The State of the Union in UK Physics Teaching

Contributed – Ross K. Galloway, University of Edinburgh, School of Physics and Astronomy, Edinburgh, Midlothian EH9 3JZ UK; ross.galloway@ed.ac.uk

Judy Hardy, Olivia Johnson, Sally Hancock, Marsali Wallace, University of Edinburgh

The Fostering Learning Improvements in Physics (FLIP) project has examined in detail the state of Physics Education Research in the UK, how PER has impacted on the teaching and learning of physics, and how physics teaching develops in practice. The project was commissioned by the Institute of Physics (the UK's professional body in physics) and by the Economic and Social Research Council to determine how best to facilitate the growth of PER in the UK. FLIP has provided a detailed and comprehensive picture of UK PER and also of the key challenges facing effective teaching and learning of physics. We will present some of the key findings, contrasting them with the situation in the US and elsewhere in the world, and discuss the wider implications.

ED11: 2:40-2:50 p.m. Spatial Reasoning Ability and the Construction of Integrals in Physics

Contributed – Nathaniel Amos, The Ohio State University, Columbus, OH 43214; nr_amos@hotmail.com

Andrew Heckler, Ohio State University

Numerous studies indicate that spatial reasoning can play a role in STEM field success. Introductory university physics frequently requires students to construct integrals, a skill that may be influenced by spatial reasoning proficiency. We administered a straightforward physics problem requiring the construction of an integral to students enrolled in calculus-based introductory physics, and additionally measured their spatial reasoning ability using the Santa Barbara Solids Test. We found that the spatial reasoning score correlates moderately with overall performance on the integration task, as well as with various components of integral setup, such as correctly identifying cross-sectional area. Furthermore, we found that students who demonstrated a physical understanding of the integrand, via a simple multiple-choice question, were significantly more successful in constructing the integral, independent of spatial reasoning ability.These results suggest that, separately, both spatial reasoning and physical understanding of the integrand are important for constructing integrals in physics.

ED12: 2:50-3 p.m. Understanding Factors Impacting FCI Gains

Contributed – Michele McColgan, Siena College, Loudonville, NY 12211; mmccolgan@siena.edu

John Moustakas, George Hassel, Rose Finn Siena College

This study aims to determine critical factors that explain differences in FCI gains among sections of algebra-based and calculus-based classes. In this study, FCI pre-test scores are found to be only moderately correlated with FCI post-scores and normalized gains, and Lawson CTSR scores are only weakly correlated. We conclude that measures of scientific reasoning ability and the level of prior knowledge of physics are not the most important factors in explaining course section differences. We report also on the development of a rubric for quantifying the degree of FCI content coverage. This work contributes to the PER community's efforts to identify a sufficiently complete set of factors impacting FCI gains and to determine the relative importance of the factors. Work in this area could guide curriculum reform to reduce students' misconceptions about Newtonian Thinking and allow them to learn more physics beyond the topics addressed by FCI.

Session EE: Same Physics Other Ways

Location: Tate Lab 170
Sponsor: Committee on Apparatus
Date: Tuesday, July 29
Time: 1–3 p.m.

Presider: David Kardelis

EE01: 1-1:30 p.m. Restaging Classic Physics Demonstrations with Illumination and Virtual Instrumentation

Invited – Urs Lauterburg, Physics Institute, University of Bern, Sidlerstrasse 5 Bern, BE 3012 Switzerland; urs.lauterburg@space.unibe.ch

Demonstrations are a vital part of the introductory physics lectures for science majors at the University of Bern, Switzerland. Performing the demos using a mix of modern techniques such as video projections, alternative lighting, and LabVIEW virtual instrumentation helps to emphasize the physical content. This allows the students to focus on the concepts involved. Some examples of how classic demonstration experiments are performed at the University of Bern's physics department are shown and discussed.

EE02: 1:30-2 p.m. Some Student-Centered Ways to Teach Physics Concepts

Invited – Duane B. Merrell, Brigham Young University, Provo, UT 84602; duane_merrell@byu.edu

Physics teaching to a first-time student should be an exciting adventure. Using the idea of the "Same Physics Different Ways" I will outline how a rural high school grew its physics programs from one class to seven classes of physics. Highlighted will be physics activities and projects that my students still ask me about when I run into them 30 years later. The big ideas of the class from projects to problems all will be shared.

EE03: 2-2:10 p.m. Using Direct Measurement Videos to Teach Introductory Mechanics

Contributed – Matthew Ted Vonk, University of Wisconsin, River Falls, River Falls, WI 54022; matthew.vonk@uwrf.edu

The video format has many advantages over other forms of information transfer. Videos lend themselves to group work and generate more discussion than written problems because the real world is more compelling, opened-ended, and messy than the sanitized versions of reality that physics students often deal with. For this reason (as well as many others) my collaborators and I have been working to create a library of short, high-quality videos of real situations that allow students to directly analyze and measure phenomena. In this talk I will discuss the advantages of using Direct Measurement Videos and will share highlights from our video library.

EE04: 2:10-2:20 p.m. Ten New Physics Experiments with iPhone Slow Motion

Contributed – James J. Lincoln, Tarbut V' Torah HS, Irvine, CA 92603; James@PhysicsVideos.net

We have seen for many years the iPhone being a useful tool in the Physics Classroom. But now, there is a new feature that is ready to make big changes. The slow motion feature on the iPhone 5s provides a convenient enhancement for many physics demonstrations, both old and new, and in some cases it enables experiments that were previously impossible! In this talk I highlight 10 of these and provide tips for successful slow motion videos.

EE05: 2:20-2:30 p.m. Slow-Speed Video

Contributed – Paul M. Nord, Valparaiso University, Valparaiso, IN 46383-5000; Paul.Nord@valpo.edu

No sense in our bodies overwhelms the others more than vision. The digital age has recently brought imaging technology at an affordable price. We can slow the ultra-fast splatter of a raindrop to a humanly understandable speed. We can see a world of things that happen in the blink of an eye. At the other end of the speed spectrum are those interactions that happen so slowly that the instantaneous motion cannot be perceived. The motion of the hour hand of a clock, the formation of an icicle, the melting of snow, or the oozing of a thick liquid all take so long that we cannot perceive the change. This talk will demonstrate a few new technological tricks to bring slow motions up to the scale of human perception.

EE06: 2:30-2:40 p.m. Hearing the Spectral Components of a Sung Vowel

Contributed – Lyle R. Lichty, Cornell College, Mount Vernon, IA 52314; llichty@cornellcollege.edu

I will demonstrate a new and fun twist on an old standby. In the past we would use a PASCO Fourier Synthesizer to create an audible square wave from its Fourier components. By attenuating or enhancing a particular component in the square wave, students could distinguish that particular component once the full square wave was played again. With modern acoustic software packages this same demonstration can be performed using a recorded human voice instead of a square wave. A vowel sound sung by the instructor or a student is recorded. During a middle time segment of the vowel, one or more components are filtered out. The original vowel sound is played, followed by the filtered vowel and the original vowel again. Distinguishing the filtered components in the original sound can be both surprising and enlightening.

EE07: 2:40-2:50 p.m. Old(?) Labs New(!?) Tricks

Contributed – David E. Sturm, University of Maine, Department of Physics & Astronomy, Orono, ME 04469; sturmde@maine.edu

A look at a few "new" introductory lab ideas that aren't as new as they seem, and at some "old" standards included in texts of collected labs such as those by Cioffari or Wilson. These "old" standards still can be done with "pre-owned" apparatus, but with a team approach and "modern" (since 1905??) methodology.

EE08: 2:50-3 p.m. Chasing Aurora: Learning Astronomy Through the STEAM

Contributed – Richard P. Hechter, University of Manitoba, Faculty of Education, Winnipeg, MB R3T2N2 Canada; richard.hechter@umanitoba.ca

Making curriculum relevant and meaningful for students is critical to enhanced teaching and learning experiences. The Chasing Aurora Project, conducted in rural and northern Manitoba where the aurora borealis appears beautifully throughout the year was designed to teach the grade 9 astronomy cluster in a new and focused way by using the aurora borealis as the foundation for learning. This presentation will share elements of the project through which secondary-level students engaged in all elements of STEAM (Science Technology Engineering Art and Mathematics) as part of their learning of astronomy. Specifically, student-taken photographs, art work, and calculations will be presented and triangulated with their comments and reflections towards using the natural world around them as the context for greater learning and exploration of this cluster.

Session EF: The Role and Implementation of Upper-level E&M

Location: Tate Lab 131
Sponsor: Committee on Physics in Undergraduate Education
Date: Tuesday, July 29
Time: 1–2:30 p.m.

Presider: Juan Burciaga

EF01: 1-1:30 p.m. Teaching Upper-Division Electromagnetism in the Paradigms in Physics Program*

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

Justyna Zwolak, Emily Smith, Michael Goldtrap, Oregon State University

To improve conceptual learning, the Paradigms in Physics program has reordered material from the subdisciplines and incorporated modern pedagogical strategies. In the electromagnetism part of our curriculum, we have: (1) reordered the content, e.g. to present potentials before electric fields; (2) exploited the geometric definitions of concepts like divergence and curl; (3) emphasized multiple representations, including kinesthetic representations of three dimensional geometry; (4) used the notion of accumulation (chopping and adding) for integral versions of fundamental laws; and (5) employed a wide variety of active-engagement pedagogical strategies. We will discuss some of these changes and present student results from new assessment protocols such as the CUE and ACER.

*This material is based on work supported by the National Science Foundation under Grant Nos. DUE 9653250, 0231194, 0618877, 1023120, 1323800.

EF02: 1:30-2:00 p.m. A Research-validated Approach to Transforming Upper-division E&M: Issues and Measures

Invited – Steven J. Pollock, University of Colorado, Boulder 390 UCB, Boulder, CO 80309; steven.pollock@colorado.edu

Upper-division E&M is traditionally taught using a lecture approach that does not make use of many of the instructional techniques that have been found to improve student learning at the introductory level. At the University of Colorado, we are transforming upper-division E&M (and other courses) using principles of active engagement and learning theory. We are guided by extensive faculty conversations on course-level learning goals. Our work builds on a research base of observations, interviews, and analysis of student work. Here I will outline the nature of the consensus learning goals we developed, and some associated assessments and pedagogical transformations. We have examined the effectiveness of these reforms relative to traditional courses based on grades, interviews, and both attitudinal and conceptual surveys. This approach provides insights into the process and structure of curriculum and pedagogical change, as well as into student difficulties in these advanced undergraduate areas.

EF03: 2-2:10 p.m. Ongoing Validation of an Upper-division Electrodynamics Conceptual Assessment Tool

Contributed – Qing Xu Ryan, University of Colorado, Boulder 390 UCB, Boulder, CO 80309; xuqing12357@gmail.com

Cecilia Astolfi, Charles Baily, University of St Andrews

Steven Pollock, University of Colorado, Boulder

As part of an ongoing project to investigate student learning in upper-division electrodynamics (E&M II), the PER research group at CU Boulder has developed a tool to assess student conceptual understanding (the CURrENT: Colorado UppeR-division ElectrodyNamics Test). This instrument is motivated in part by our faculty-consensus learning goals and can serve to measure the effectiveness of transformed pedagogy. In this talk, we present measures of the validity and reliability of the instrument and scoring rubric. These include expert validation and student interviews, inter-rater reliability measures, and classical test statistics. This work is supported by the University of Colorado and NSF-CCLI grant #1023208.

EF04: 2:10-2:20 p.m. Integration in Electrostatics with a Computational Perspective

Contributed – David Roundy, Oregon State University, Department of Physics, Corvallis, OR 97331-8507; roundyd@physics.oregonstate.edu

Eric J. Krebs, Jeff B. Schulte, Oregon State University

Many students struggle to understand and use the principles of "chopping and adding" when integrating over a charge distribution to find the electrostatic potential or electric field. I will introduce a sequence of computational lab activities that help students to better grasp these concepts by writing python programs to compute these quantities numerically. Thus the students are literally adding up the potential (or field) due to small chunks of charge, which provides a perspective on integration in three dimensions that is complementary to the perspective students bring from their calculus courses. Theses activities have been developed as part of a laboratory course that runs parallel to the Paradigms in Physics sequence, and teaches the same physics content. However, the activities and the course should require little modification to work alongside a traditional course in electromagnetism. This work is funded by the NSF grant DUE-1141330.

Session EG: What Can PER Contribute to the Design of High Quality Distance Education?

Location: Tate Lab 166
Sponsor: Committee on Educational Technologies
Co-Sponsor: Committee on Research in Physics Education
Date: Tuesday, July 29
Time: 1–3 p.m.

Presider: Ted Hodapp

EG01: 1-1:30 p.m. Distance Education and Online Learning: Critical Lessons from the Conference

Invited – Theodore Hodapp, American Physical Society, One Physics Ellipse, College Park, MD 20740; hodapp@aps.org

In June 2013, the American Physical Society (APS) in cooperation with AAPT brought together individuals who have been using and experimenting with distance education and online learning environments and tools. Topics included Massive Open Online Courses (MOOCs), online on-campus courses, flipped classrooms, and electronic resources available to faculty and students. Education researchers discussed topics including cheating, assessments, simulations, and research agendas. This talk will provide an overview of broad and specific lessons from the presentations and discussions during the gathering. We hope to continue the discussions at this meeting—please bring your thoughts, concerns, and questions.

EG02: 1:30-2 p.m. MOOC-ing, Flipping and Blending Introductory Physics Lecture and Lab

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

We describe an effort to develop and to implement a college-level introductory physics (mechanics) course and laboratory as both a flipped/blended experience for on-campus students and, simultaneously, a Massively Open Online Course (MOOC) for off-campus participants. The course emphasizes a "Your World is Your Lab" approach whereby students first examine and capture on video (using cellphones) motion in their immediate surroundings, and then use free, open-source software both to extract data from the video and to apply physics principles to build models that describe, predict, and visualize the observations. Each student reports findings by creating a video lab report and posting it online; these video lab reports are then distributed to the rest of the class for peer review. In this talk, we describe a research-based approach to implementing and testing peer review methods, including a statistical analysis of student vs. expert grading and coding of student essay comments on peer work. We will also discuss the analysis of clickstream data from student interactions with lecture videos as a tool for improving the delivery of course content.

EG03: 2-2:30 p.m. If You Don't Know Where You're Going, You Might Wind up Someplace Else

Invited – Mats Selen, University of Illinois, Department of Physics, Urbana, IL 61801; mats@illinois.edu

As we ponder the future of education, we know that online components will play an ever increasing role. We anticipate that 10 years from now the educational landscape will be quite different than it is today. Indeed, advances in online educational technology have put us in the interesting position of having the tools to get there without really knowing where to go. This is a great opportunity for PER to lead the way, but the stakes are high and the questions are profound: What are the key outcomes of a post-secondary STEM education? How can these outcomes be assessed? Which ones can be achieved online? How do we reward the creation and dissemination quality online content? We explore these issues and suggest possible solutions.

EG04: 2:30-3 p.m. How to Reduce Unproductive and Undesirable Behavior in Online Courses

Invited – Gerd Kortemeyer, Michigan State University, Holmes Hall, East Lansing, MI 48825; korte@lite.msu.edu

One of the most frustrating components of educators' work is having to deal with academic integrity issues. These span from "gaming the system" and unauthorized or unproductive collaborations to plagiarism and plain cheating: learners are betraying their educators, fellow students, and eventually themselves. Particularly in online courses, the creation and maintenance of a culture of academic integrity is seen as a growing and badly understood challenge. This talk discusses research on student work and interaction patterns, and presents interventions to foster productive engagement with course content.

Session EH: Histories Useful for Teaching Physics

Location: STSS 114
Sponsor: Committee on History and Philosophy in Physics
Date: Tuesday, July 29
Time: 1–2:40 p.m.

Presider: Ruth Howes

EH01: 1-1:30 p.m. Teaching the Physics of an Early Attempt at Medical Imaging

Invited – Dean Zollman, Kansas State University, Manhattan, KS 66506-2601; dzollman@phys.ksu.edu

Johannes v.d. Wirjawan Widya, Mandala Catholic University at Surabaya, Indonesia

Sytil Murphy, Shepherd University

Nora Norvelle, Cornell University

President James Garfield was shot on July 2, 1881. Knowledge of location of a bullet that was lodged deep in President Garfield's body was needed by physicians trying to save Garfield's life. Alexander Graham Bell proposed that he use his newly invented telephone and an induction balance to locate the bullet.[1] Bell's device was, in effect, the first metal detector and the first attempt at medical imaging without surgery. His device successfully detected metal in carcasses of animals and in Civil War veterans but the attempt to find the bullet in Garfield was not successful. A combination of scientific, political, and personal reasons led to Bell's failure.[2] The scientific aspects provide a good way for students to learn several concepts in electromagnetism and AC circuits. We have created a set of lessons that helps students understand both Bell's ideas and his failure. The lesson may downloaded at http://web.phys.ksu.edu/mmmm/.

1. Alexander Graham Bell "Upon the Electrical Experiments to determine the location of the Bullet in the body of the late President Garfield and upon the successful form of Induction Balance for the painless detection of Metallic Mass in the Human Body" *Am. J. of Sci.* **25**, 22-61, 1883
2. Candice Millard, *Destiny of the Republic: A Tale of Madness, Medicine and the Murder of a President,* (New York: Doubleday Publishers, 2011).

EH02: 1:30-2 p.m. Does Social Constructivism Translate from History to Education?

Invited – Shawn Reeves, EnergyTeachers.org, Ithaca, NY 14851-0670; shawn@energyteachers.org

What is it that physicists do? How do they make decisions? How do they find success? Historians help answer these questions; so, historians should be able help us answer these questions with students. But teachers and students also struggle with the same problems that vex historians, those concerning agency, priority, motivation, and interactions. Knowledge doesn't exist outside of us, nor does it reside solely in individuals, but it messily travels in society. We are better teachers when we coach students through the classroom and through society with tools that let students consider themselves a part of physics and physics a part of their society. We will discuss how the historiography of energy physics in 19th century Britain went constructivist, and whether that inspires us.

EH03: 2-2:10 p.m. The Spheres of Eudoxus

Contributed – Todd K. Timberlake, Berry College, Mount Berry, GA 30149-5004; ttimberlake@berry.edu

In the 4th Century BCE, the Greek astronomer and mathematician Eudoxus of Cnidus developed a geometrical model to explain the observed motion of the planets. His model consisted of a series of connected, rotating spheres, all centered on the Earth. I will discuss the key features of Eudoxus' model (as reconstructed by Giovanni Schiaparelli in 1875) and present an open-source computer simulation that illustrates the model. I will discuss both the successes and the flaws of this model, and explain how a basic understanding of Eudoxan astronomy can help students appreciate the power and beauty of the later Ptolemaic astronomy. The computer simulation is available from the Open Source Physics collection at www.compadre.org/osp/.

EH04: 2:10-2:20 p.m. Reading Galileo's Dialogues in a Course on Scientific Reasoning

Contributed – James Simmons, Shawnee State University, Portsmouth, OH 45662; jsimmons@shawnee.edu

In a general-education science course at Shawnee State University, students read selections from Galileo's Dialogue Concerning the Two Chief World Systems. This talk describes what students seem to learn from the experience and what aspects of scientific reasoning are illustrated by Galileo's Dialogue.

EH05: 2:20-2:30 p.m. Historical Development of Ideas About Light, Color and Vision

Contributed – Scott Bonham, Western Kentucky University, Bowling Green, KY 42101; Scott.Bonham@wku.edu

A major goal of general education is an understanding of the nature and process of science. My course Light, Color and Vision addresses this in part through reading and discussing historical development of ideas about light, color and vision. Not only do students learn about different important figures such as Alhazan, Fresnel, Michelson, and Einstein, they read selections written by Aristotle, Huygens, Newton and Maxwell on the nature of light and color. As many students have never before read these kinds of texts, I find it important to provide them guides to direct and class discussion time to help them process their reading. Not only does this approach provide my students with a new perspective on the subject and how science works, but gives some of my students who struggle with the quantitative components of the course a way to engage with science that plays more to their strengths.

EH06: 2:30-2:40 p.m. Why Benjamin Thompson Began to Study Heat

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

Benjamin Thompson was an American farm boy. The first years of his life were a struggle to obtain an education. When he was sent as a school teacher to Concord, NH, he acquired a rich wife and the interest of the British governor who enjoyed science and was able to afford to pursue it. Thompson acquired an interest in science which was nourished by his attempts to establish himself in society through a military career that took him to England, back to the U.S. and ultimately to Bavaria. His approach to problems of the nature of heat was always motivated by practical applications, such as the Rumford fireplace. Thompson's story is a tale of a gifted scientist who never had formal education in the field. His story should thus serve as an object lesson for students who love to solve practical problems.

Session EI: Best Practices in Educational Technology I

Location: STSS 230
Sponsor: Committee on Educational Technologies
Date: Tuesday, July 29
Time: 1–2 p.m.

Presider: Aaron Titus

EI01: 1-1:30 p.m. Using Direct Measurement Video to Teach Science Practices

Invited – Peter Bohacek, Henry Sibley High School, Mendota Heights, MN 55118; peter.bohacek@isd197.org

Direct Measurement Videos are short, high-quality recordings of events with overlaid graphics that allow students to make precise measurements directly from the video. Our growing collection of videos provides an alternative to word problems, showing vivid examples of events (skidding cars, looping roller coasters, hockey slap shots) that can be analyzed using physics concepts. In this talk, we will discuss three aspects of the current project. We'll describe how Direct Measurement Videos and our instructional support materials can be used in the classroom, and in particular, in the teaching of the practice of science (consistent with the Next Generation Science Standards and new AP Physics curricula). We'll show progress towards a web-based video player with scalable, movable grids, rulers, and protractors that allow students to decide what and how to measure on the video. In addition, we'll show some of our newest Direct Measurement Videos. Direct Measurement Video Website: http://serc.carleton.edu/dmvideos/index.html

EI02: 1:30-2 p.m. Writing Electronic Books with Interactive Curricular Material*

Invited – Mario Belloni, Davidson College, Physics Department, Davidson, NC 28035-6910; mabelloni@davidson.edu

Wolfgang Christian, Kristen Thompson, Davidson College

With the rise of tablets, such as the iPad, the past few years have seen an increase in the demand for quality electronic textbooks. Unfortunately most of the current offerings do not exploit the accessibility and interactivity that electronic books can deliver. For astronomy and physics electronic textbooks, support for typesetting of equations (MathML) and interactive simulations (JavaScript) are necessary. In this talk we will discuss how our curriculum development projects (Physlets, Easy Java/JavaScript Simulations, and Open Source Physics) are merging with the EPUB electronic book format. Specifically we will discuss the EPUB format and how we are taking an iterative approach to producing interactive electronic books for astronomy and physics.

*This work was supported in part by an Innovation Grant from Davidson College.

Session EJ: Technologies

Location: STSS 230
Sponsor: AAPT
Date: Tuesday, July 29
Time: 2–3 p.m.

Presider: Gary Baier

EJ01: 2-2:10 p.m. Effect of Electronic Homework on Small College Physics Courses

Contributed – Kristen A. Thompson, Loras College, Dubuque, IA 52004-0178; Kristen.Thompson@loras.edu

This report describes the impact of switching to an online homework system (Moodle) in a small liberal arts college environment for introductory algebra and calculus-based physics courses. As a first step, this study looks at the online homework's effectiveness by examining homework and test scores on both conceptual and numerical problems. This study also looks at the effect of online homework on instructor-student interaction and best practices working within the constraints of the Moodle system.

EJ02: 2:10-2:20 p.m. Student Strategies When Doing Problems

Contributed – David Pritchard, MIT, 77 Massachusetts Ave., Cambridge, MA 02139; dpritch@mit.edu

John Champaign, Qian Zhou, Kimberly Colvin, MIT

Raluca Teodorescu, George Washington University

Using complete logs of student activities from Massive Open Online Courses (MOOCs), the RELATE group (http://RELATE.MIT.edu) has examined student strategies when doing problems. When students get an answer wrong, what resources do they use most frequently, for the longest time, and in which order. For example, do they look at worked examples and then read the textbook—or the other way around? What strategy correlates with outcomes (if any) such as score on assessment, skills as defined by Item Response Theory, improvement in skill over the course and pre-/post-testing. The wide distribution of demographics and skills that MOOCs allow provides new challenges in isolating the habits of learning and resource usage of various student cohorts. This is part of the overall RELATE program for discovering the specifics of learning in the first-year undergraduate physics domain.

EJ03: 2:20-2:30 p.m. iDevices as Lab, Data, & Analysis Tools

Contributed – Taoufik Nadji, InterlochenArts Academy, 4000 Highway M-137 Interlochen, MI 49643; NADJIT@INTERLOCHEN.org

The presenter will share a variety of experiments (including the one featured in TPT) that he conducts in his classes using iDevices (iPads, iPods, & iPhones) as data gathering, analyses, and lab tools. The presentation will feature actual footages of the said experiments as conducted with the students and the attendees will participate in at least two such experiments.

EJ04: 2:30-2:40 p.m. Physics of the Beatles

Contributed – David Keeports, Mills College, Department of Chemistry and Physics, Oakland, CA 94613; dave@mills.edu

The Beatles made their first Ed Sullivan Show appearance on the evening of Feb. 9, 1964. I will present a talk that I wrote for my students to commemorate the 50th anniversary of the arrival of Beatlemania in America. Innovation pervades the songs of the Beatles, and much of that innovation lies in sound recording techniques pioneered by their young engineer, Geoff Emerick. I will focus upon recording techniques in Beatles songs that are accessible to introductory physics students. Topics I will discuss include the audible spectrum of a guitar band, the use of vocal doubling, the bright sound of Vox amplifiers, novel uses of microphones and speakers, guitar feedback as musical sound, sound sampling, and envelope reversal. I will present numerous sound demonstrations that I constructed by using Logic, Apple's digital audio workstation.

EJ05: 2:40-2:50 p.m. Learning Astronomy from "Experience"

Contributed – Kara Beauchamp, Cornell College, Mount Vernon, IA 52314; kbeauchamp@cornellcollege.edu

Many students come into our introductory astronomy classes with very little experience with the nighttime (or even the daytime) sky, yet they take concepts such as the structure of the solar system as self-evident, because they have been taught them from such a young age. While knowledge of the structure of the solar system is an important part of our scientific heritage, it is equally important for students to gain an appreciation of how that knowledge was developed. One step in that process is understanding retrograde motion of planets in the sky. It's one thing to read about retrograde motion and look at images in a textbook, and another thing to "observe" retrograde motion. Here I present an assignment in which students use a free planetarium program to simulate observation of the position of Mars over different timescales for several years, and then describe those observations.

APS Plenary: Sponsored by the Division of Particles and Fields

Location: Northrop Auditorium
Date: Tuesday, July 29
Time: 3:30–5 p.m.

Presider: Ken Heller

Rioger Rusack

1. Physics at the CERN Large Hadron Collider, the Past, the Present and the Future

Roger Rusack, School of Physics and Astronomy, University of Minnesota

Physicists working at the Energy Frontier using the Large Hadron Collider (LHC) at CERN announced last year the observation of the Higgs boson at 125.6 GeV. I will tell a small part of the story of what we did to be able to make that announcement and discuss what is happening now at the LHC as we get ready to start data taking at double the collision energy. I will also speak about the plans for the future and possibilities that lie ahead.

Lucy Fortson

2. Explorations in the Cosmic Frontier: Shedding Light on the Dark?

Lucy Fortson, School of Physics and Astronomy, University of Minnesota

The last decade has seen an amazing investment in instruments in particle astrophysics. These experiments are exploring the "cosmic frontier" in an effort to find the answers to some of the biggest questions in physics: What is Dark Energy? What is the nature of Dark Matter and what is it going to take to discover it? What is the physics of the high-energy Universe and where do the highest-energy cosmic rays come from? In this round-up of the cosmic frontier, I will review what we are learning about these "big questions" with a focus on some of the progress made in the effort to detect Dark Matter, both with direct detection experiments such as CDMS and indirect detection through the use of very high-energy photons observed by VERITAS. Along the way, I will touch on topics such as the characteristics of Nature's particle accelerators – astrophysical jets emanating from supermassive black holes at the centers of active galaxies and how we can use their emissions as probes of the existence of a specific Dark-Matter candidate-Axion-like particles.

Dan Cronin-Hennessy

3. The Turn of the Screw: A Chilling Ghost Story of Nature's Most Unusual Fermion

Dan Cronin-Hennessy, School of Physics and Astronomy, University of Minnesota

The Standard Model of particle physics is arguably the most successful theory ever and yet we still do not have a proper theory of flavor. Working at the Intensity Frontier, the flavor oscillations of neutrinos provide crucial information concerning mass, mixing, and the matter/anti-matter asymmetry of our Universe. I will review several of the most active areas of particle physics that exploit the neutrinos' unique properties in order to advance our knowledge of fundamental laws.

PST2: Poster Session 2

Location: Coffman Union ground floor
Date: Tuesday, July 29
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 may be set up starting at 8 a.m. Tuesday and then should be taken down by 6:30 p.m. Tuesday)

A – Physics and Society Posters

PST2A01: 5-5:45 p.m. Science and Religion

Poster – Madhuri Bapat, Eastern Arizona College, Thatcher, AZ 85552; durga1950@hotmail.com

Many physicists (Fritjof Capra, David Baum) in the past have tried to relate science with religion. I have made an attempt to find a parallel between Hindu philosophy and science. Birth, life, and death are seen as effects of four fundamental forces combined in various manners. Reincarnation and Moakhsha or Nirvana are seen as principles in physics such as conservation of energy, and converting mass into energy. Controlling enemies such as greed, pride, anger, jealousy, and sorrow are seen as controlling degenerative forces such as friction, resistance, etc. Soul is perceived as a wave that carries all four fundamental energies—electromagnetic, gravitational, nuclear, and atomic. Meditation is perceived as controlling electron transitions in brain. Emotions are seen as biochemicals produced in brain. This model is neither complete nor even close to accurate. However it invites more brain storming from interested folks.

PST2A02: 5:45-6:30 p.m. Student Attitudes Toward Science: Baseline Data

Poster – Shannon D. Willoughby, Montana State University, Bozeman, MT 59717; willoughby@physics.montana.edu

Keith Johnson, Montana State University

Nationwide student attitudes toward science and students' perceived ability to learn science tend to decrease through the semester in traditionally taught physics and astronomy courses. A recent study[1] has shown that more explicit inclusion of the nature of science and science versus pseudoscience in an introductory astronomy course has resulted in increased student attitudes toward the relevance of science in their daily lives as well as students' perceived abilities to learn science. In order to gauge the change in student attitudes in Astronomy 110 locally, we have given the Epistemological Beliefs about the Physical Sciences[2] survey for four semesters. Overall results are similar to those seen nationwide, but when broken down by gender some surprising results emerge.

1. D. Duncan and L. Arthurs, "Improving Student Attitudes about Learning Science and Student Scientific Reasoning Skills," *Astro. Educ. Review* **11** 010102 (2012).
2. http://www2.physics.umd.edu/~elby/EBAPS/home.htm

PST2A03: 5-5:45 p.m. Establishing an Ancient Cosmos (in the Creation Museum's Backyard)

Poster – Richard Gelderman, Hardin Planetarium, Western Kentucky University, Bowling Green, KY 42101-1077; gelderman@wku.edu

The Creation Museum, located in northern Kentucky near Cincinnati, presents a "young Earth" account of the origins of the Universe and life on Earth, according to a literal reading of the Book of Genesis. Because this high production-value museum experience is an easy day trip for people in our region, we have explicitly incorporated into our presentations the strategies that we hope can counter young Earth teachings. We share examples of investigative activities to establish cosmic timescales. However, we have found that reinforcing the practices of science is a more important aspect of our instruction than factual content. We argue that the bulk of our time is best spent engaging students in processes by which they create and test potential explanations as scientists.

PST2A05: 5-5:45 p.m. Engaging Physics Majors with Academic Civic Engagement Projects

Poster – Melissa A. Eblen Zayas, Carleton College, 1 North College St., Northfield, MN 55057; meblenza@carleton.edu

How to prepare students to become engaged citizens and apply their physics knowledge to social problems is often an afterthought in the undergraduate physics curriculum. Academic civic engagement projects, both in traditional classes and beyond standard coursework, provide a powerful opportunity for students to bring their knowledge to bear on local community issues. I will present several examples of the types of academic civic engagement projects I have had students work on as well as highlighting the benefits and challenges of this type of work.

PST2A07: 5-5:45 p.m. Demonstrations for Outreach on Energy Topics

Poster – David E. Sturm, University of Maine, Department of Physics & Astronomy, Orono, ME 04469; sturmde@maine.edu

A compilation of demonstrations found useful with the Mainely Physics Road Show in lecture-style presentations on the topic of energy (particularly electrical energy) to the middle school audience.

PST2A08: 5:45-6:30 p.m. Crazy, Cool, Controversial: Real-world Radiation and Nuclear Technology Topics

Poster – Kathryn Schaffer, 112 S. Michigan Ave., Chicago, IL 60603; kschaf2@saic.edu

Radiation is everywhere. This is true in a literal sense, but also in the sense that news stories, pop-culture references, historical oddities, technological applications, and cultural artifacts that relate to radiation and nuclear technology are abundant. These provide rich fodder for class discussion and intriguing entry-points for learning physics. This poster will highlight some favorites from a course that devotes an hour a week to discussing the "nuclear news" and student-selected curiosities. A handout will present a collection of over 50 topics to consider for enriching classroom discussion of radiation, radioactivity, and nuclear technology, ranging from the radiation environment in space to nuclear weapons imagery in contemporary fashion.

PST2A09: 5-5:45 p.m. Can Small Boxes Model the Atmospheric Greenhouse?

Poster – Thomas C. Gibbons, Retired, 707 8th Ave. S, Clinton, IA 52732; tomgib@mchsi.com

Atmospheric trapping of infrared leads to a warmer surface, but there has been questioning about whether solar collectors and greenhouses also act in this way. These systems also control convection, which might be responsible for the warmer temperatures. Schools need models of the atmospheric greenhouse but should not use models that actually demonstrate something else. I have used small boxes resembling solar collectors with a black absorbing interior but covered by materials of differing infrared transmission properties. After determining relative infrared transmission ability using two methods, I measured their interior temperatures with varying degrees of insolation and ambient temperature. Whenever infrared transmission differences were clear, the greater transmission (smaller trapping) corresponded to a lower internal temperature. This leads to greater confidence that infrared trapping in these devices does affect their temperatures, thus crudely modeling atmospheric effects, regardless of any convection effects present.

PST2A10: 5:45-6:30 p.m. Analysis of Carbon Dioxide's IR Absorption Ratio

Poster– Suyeong Kim Hansung, Science High School, 279-79 TonilRo SeoDaeMoonGu, Seoul, 120-080 Republic of Korea; syap713@naver.com

People around the globe have been concerned about greenhouse effect for decades. Greenhouse effect is caused by man-made gases, such as carbon dioxide. It is said that carbon dioxide in the atmosphere absorbs IR light, while the quantitative data tells the absorbing rate according to the density and thickness of carbon dioxide gas. We developed the method to measure the absorbing ratio of IR light due to the density and thickness with simple equipments.

PST2A11: 5-5:45 p.m. Observing Students' Science Learning Activity in the Elementary School Classrooms

Poster – YoungSeon Mz Seo, Seoul National University of Education,Seocho 1-dong, Seocho-gu Seoul, Seoul 137-742 Rep. of KOREA; miseo95@hanmail.net

The unbalance of intelligence development can be found with ease in low grade classes of elementary school. Lingual activities are dominant in a science class as well as the other classes. Logic and mathematics are also essential features in a science lesson. Therefore, the students who lag behind in developing language and mathematics skills often have difficulty in keeping up with the classes regardless of their interest and talent in science. Also it will let the students fall into a chronically learning frustration that is hard to get out of. We have observed the students' activities in low grade classes to find out how the students are different in intelligence development. As a consequence of this research, we hope to suggest a teaching and learning strategy in science class for the students who are late in the development of verbal linguistic and logical mathematical intelligence.

B – Lecture and Classroom Posters

PST2B01: 5-5:45 p.m. Observing Students' Science Learning Activity in the Elementary School Classrooms

Poster – YoungSeon Mz Seo, Seoul National University of Education,Seocho 1-dong, Seocho-gu Seoul, Seoul 137-742 Rep. of KOREA; miseo95@hanmail.net

The unbalance of intelligence development can be found with ease in low grade classes of elementary school. Lingual activities are dominant in a science class as well as the other classes. Logics and mathematics are also essential features in a science lesson. Therefore, the students who lag behind in developing language and mathematics skills often have difficulty in keeping up with the classes regardless of their interest and talent in science, in turn, it will let the students fall onto a chronically learning frustration that is hard to get recovered. We have observed the students' activities in low grade classes to find out how the students are different in intelligence development. As a consequence of this research, we hope to suggest a teaching and learning strategy in science class for the students who are late in the development of verbal linguistic and logical mathematical intelligence.

PST2B02: 5:45-6:30 p.m. A Story of a Boy Who Loves Machines--Analyzing the School Life of a 1st Grade Student Whose Talents Are Unbalanced

Poster – Hye Young Seo, Seoul National University of Education 96, Seouchojungang-ro, Seocho-gu Seoul, 137-742 South Korea; rubi0426@hotmail.com

Gardner's theory of multiple intelligence suggests all people have different kinds of intelligences. In other words, individuals have their own intelligence profiles as the strengths of each eight intelligences. But these are not enough to explain various profiles in which such intelligences are invoked and combined to carry out the tasks, solve diverse problems, and progress in various domains. The subject of this case study is a 1st grade student who shows particularly great talent and creativity in machines but has unbalanced intelligence development. We analyzed his various characteristics through the observation of the school life, interviews and one-to-one class according to Howard Gardner's multiple intelligence theory. As a consequence of the research, we discovered the possibility of the engineering intelligence existence.

PST2B03: 5-5:45 p.m. Active Learning Samples

Poster – Gowoon Choi, Florence Darlington Technical College, PO BOX 100548, Florence, SC 29502; gowoon.choi@fdtc.edu

Several active learning samples will be displayed as follows: 1. An idea of a fun, first class activity: Building an easy-to make balloon-powered car from a given template and everyday materials like straw, coffee stirrer,...etc. Students are led to compete with their own racing cars in class. A template, a built-in sample car, students' misunderstandings of related concepts will be displayed. 2. A different style of lab assignment was developed. Unlike the traditional lab report format, the focus is to encourage students to describe the concepts in their own words according to qualitative labs. This after-lab writing assignment helps students understand better the lab topics. Assignment forms and evaluation grids were developed. 3. Combining Ranking task and realtime (short-checking) lab idea: when students are reluctant to accept or are not sure about the answers of some ranking task, performing an easy set-up lab about the ranking task seems to help them to accept the result. A ranking task, short-lab set-up pictures and students' responses will be displayed.

PST2B04: 5:45-6:30 p.m. Guided Inquiry Activities for a Modern Physics Course

Poster – Jane D. Flood, Muhlenberg College, 2400 Chew St., Allentown, PA 18104-5586; flood@muhlenberg.edu

The author developed guided inquiry activities to promote learning in a 200-level modern physics class. Activities organized around the spectrum of the hydrogen atom, superposition of waves, and solving the time-independent Schrodinger equation in one dimension were developed according to the principles of Project-Oriented Guided Inquiry Learning (POGIL)1. In these application activities students work in self-managed groups to deepen their understanding of previously introduced material. The poster will introduce POGIL principles and discuss development, implementation, outcomes and refinements of the modern physics activities. https://pogil.org/.

PST2B06: 5:45-6:30 p.m. Problem Solving and "Beginning with the Physical Situation"

Poster – Dennis Gilbert, 1875 Jefferson, Eugene, OR 97402-4067; gilbertd@lanecc.edu

This poster elaborates on moving students to "begin with the physical situation" in problem solving and developing conceptual understanding in calculus-based General Physics. A variety of visual tools and interventions in class discourse will be presented, which support students in transforming their approach to problems solving. These diagrams and discourse interventions also provide students tools for greater awareness of their evolving understanding of the nature of science and physics, level of knowing, problem solving, and their identity as physics learners.

PST2B07: 5-5:45 p.m. Strategies for Encouraging Qualitative Thinking During Problem Solving

Poster – Bradley K. McCoy, Azusa Pacific University, 440 W Gladstone St., Azusa, CA 91702-7000; bmccoy@apu.edu

While solving quantitative problems, novices tend to resort to formal manipulation instead of integrating physics concepts with formulas in a coherent manner. In contrast, experienced problem solvers habitually use concepts as a foundational piece of their problem solving to guide their quantitative work and to check their solutions. This poster will present strategies for training students to use qualitative thinking and incentivizing qualitative thinking, in the context of an introductory university physics course.

PST2B08: 5:45-6:30 p.m. Team Analysis And Review – Using Group Assessment for Learning

Poster – Kayt E. Frisch, Dordt College, 498 4th Ave NE, Sioux Center, IA 51250; kayt.frisch@dordt.edu

Team work is widely reported to be a highly desired skill by prospective employers and professional schools. To help my students develop teamwork skills I have been using group quizzes called "Team Analysis And Review" (TAARs) in my introductory algebra-based physics course. A TAAR takes the full 50-minute class period and the students will review the material on the quiz three times during the period: individually, in an assigned group, and finally as a whole class. The individual TAAR allows the student to identify personal gaps in their understanding of the material. The group TAAR encourages peer instruction and offers an immediate opportunity to learn from your mistakes. Reviewing the TAAR as a whole class closes the feedback loop and allows the instructor to correct any lingering student misunderstandings. Students respond favorably to the process and report that TAARs are helpful for their learning.

PST2B09: 5-5:45 p.m. Transitioning All Introductory Physics Courses to a Studio-Style Classroom

Poster – Heidi L. Manning, Concordia College, Moorhead, MN 56562; manning@cord.edu

Bryan A. Luther, Luiz A. Manzoni, Thelma S. Berquó, Mark W Gealy, Concordia College

The physics department at Concordia College in Moorhead, MN, has completed a three-year transition to implement Studio Physics pedagogy in both semesters of its calculus-based and algebra-based introductory physics courses. The goal of the Studio Physics project was to increase both student learning and the retention of STEM majors. The transition required modifications to our course schedule, teaching schedules and the classroom environment. The effectiveness of the new pedagogy was evaluated using the FMCE and the CLASS. An overview of the transition process and the results of these assessments will be presented. The project was funded by an NSF STEP grant.

PST2B10: 5:45-6:30 p.m. Using the Patterns Approach as a Comprehensive Model for Meaningful STEM Integration in the Physics Classroom

Poster – Bradford K. Hill, Southridge High School, 9625 SW 125th Ave., Beaverton, OR 97008; bradford_hill@beaverton.k12.or.us

Heather Moore, Robert E. Lee High School

Jordan Pasqualin, Rowe Clark Math and Science Academy

Mark Hartman, Millbrook High School

Scott Murphy, St. Joseph's Preparatory School

Together, the Patterns Approach for Physics, data-driven engineering projects, and computational reasoning provide a comprehensive approach to teaching and learning physics. Instruction throughout the course is framed using the question "How do we find and use patterns in nature to predict the future and understand the past?" Each instructional unit begins with scenario and accompanying research question which prompts them to an investigation. Students start by making initial guesses which is contrasted with a data-informed prediction, found through extrapolation of the pattern in the data. Additionally, each unit involves an iterative, data-driven engineering project requiring students to apply patterns of physics, mathematical problem solving, and the tools of technology to solve a problem. Throughout the experience students are repeatedly modeling the real work of scientists and engineers and thus gain a greater understanding of science and STEM careers.

PST2B12: 5:45-6:30 p.m. Learning Assistants in Introductory Physics: Successes and Challenges at WVU

Poster – Paul M. Miller, West Virginia University, Morgantown, WV 26506-6315; paul.miller@mail.wvu.edu

Jeffrey S. Carver, Kimberly Quedado, West Virginia University

In the fall of 2011, the West Virginia University Learning Assistants (LA) program began. Since the funding came as a component of a larger grant, our situation was well-suited to replication. Our program was designed after attending the LA Workshop at the University of Colorado. From the perspective of three years of LAs in our courses, we report successes, challenges, and lessons learned for both semesters of calculus-based introductory physics. We present content learning gains (from the FMCE and CSEM) and attitudes (from the CLASS) data. We show that the program has improved learning gains overall and in some targeted categories, such as first-generation students. Finally, we document and explore differences in course readiness between fall and spring enrollees that were revealed through program assessment. (This project is supported by the National Science Foundation under Grant No. EPS-1003907.)

PST2B13: 5-5:45 p.m. Modeling the Physical World: An Integrated Calculus/Physics Course

Poster – Gintaras Duda, Creighton University, Omaha, NE 68178; gkduda@creighton.edu

Randall Crist, Creighton University

A physicist and a mathematician (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 (multivariable) is paired with Physics II. This team-taught class uses a combination of lecture with active-engagement elements and project-based learning. This poster will discuss student learning in this environment, lessons learned, the benefits of this tight integration between math and physics (to both students and faculty), and potential improvements in the future. 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.

PST2B14: 5:45-6:30 p.m. Should (and Can) We Teach Forces First?

Poster – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099; pawla@uwplatt.edu

Interactions are the heart of the mechanics course and forces are the fundamental representation of interactions. Thus, from an educational theory standpoint, teaching forces first in mechanics is an attractive option. Traditional instruction in mechanics, however, begins by teaching the concept of acceleration from a kinematic perspective before introducing Newton's second law. I briefly summarize a pedagogy that illustrates the potential utility of teaching forces before kinematics and presents evidence that college students in calculus-based mechanics perform equally well in courses that begin with forces as they do in courses that begin with kinematics.

PST2B15: 5-5:45 p.m. An Introductory Physics Course that Combines Several Research-based Curricula

Poster – Kevin Calvin Goering, University of Memphis, 216 Manning Hall, Memphis, TN 38152; kgoering@memphis.edu

We report on a pilot of a first-semester calculus-based introductory physics curriculum at the University of Memphis. This curriculum incorporates elements from several different research-based curricula developed at other institutions. In order to better understand how students respond to this new curriculum, we compare student performance in a section using the redesign curriculum (n=35) to student performance in a lecture-based section (n=65) of the same course. We evaluate students' conceptual understanding, problem-solving performance and views about physics and learning physics in the two sections. Assessment methods include Force Concept Inventory (FCI) pre/post-tests, the Colorado Learning Attitudes about Science Survey (CLASS) and paired embedded exam questions.

PST2B16: 5:45-6:30 p.m. Blending Content and Practice: Designing a New Introductory Mechanics Course

Poster – Marcos D. Caballero, Michigan State University, East Lansing, MI 48824-1046; caballero@pa.msu.edu

David Stroupe, Stuart H. Tessmer, James T. Laverty, Paul W. Irving, Michigan State University

Developing students' skills with scientific practices is key for preparing science and engineering professionals, science educators, and critical consumers of scientific information. However, most undergraduate instruction in science, technology, engineering, and mathematics (STEM) severely lacks authentic scientific practice (e.g., developing and using models, designing experiments, using computational modeling). Physics courses that blend the practices of science with core physics content engage students in creative and inspiring ways that are simply not possible in traditional lecture environments. At Michigan State University, we are designing a course in which students will learn physics content by engaging in scientific practices to grapple with complex, real-world problems and by participating in multi-day projects. In this poster, we share the design principles, organization of curriculum, and sample problems and projects from this course.

PST2B17: 5-5:45 p.m. Lights, Action, Camera – Coil Gun with a Disposable Camera

Poster – Arlisa L. Richardson, Chandler-Gilbert Community College, Mesa, AZ 85212; arlisa.richardson@cgc.edu

In Physics 112, General Physics II, at Chandler-Gilbert Community College the course topics include electricity, electromagnetism, optics, and modern physics. In an attempt to create a meaningful learning experience for the students, I include various hands-on team projects, adapted from my colleague, David Weaver. These projects are designed to engage students with specific concepts in a more contextual manner. This poster presentation focuses on the Lights, Action, Camera! project, which challenges students to design and build a coil gun capable of launching a metallic BB as far as possible, using the flash circuit from a used disposable camera. This project requires students to synthesize and apply concepts of electrical circuits and electromagnetism, while working as a team to design experiments and analyze data. The details of the project's requirements and a sample of students' final projects are shared in this poster presentation.

PST2B18: 5:45-6:30 p.m. Chemical Energy in Introductory Physics for the Life Sciences

Poster – Benjamin W. Dreyfus, University of Maryland, Department of Physics, College Park, MD 20742; dreyfus@umd.edu

Benjamin D Geller, Julia Gouvea, Vashti Sawtelle, Chandra Turpen, Edward F. Redish, University of Maryland

NEXUS/Physics is an introductory physics course for life science students that seeks to build interdisciplinary coherence among physics, chemistry, and biology. Chemical energy is at the center of these efforts to make connections between disciplines, since energy is central to all three disciplines and the energy that is most relevant to biological systems is chemical energy. We have developed a curricular "thread" on chemical energy that runs throughout the course, creating materials that are available to other instructors who want to integrate similar threads into their own courses. The thread builds on the ideas that students bring into the course, from their biology and chemistry backgrounds and from their experiences in the physical world. It makes connections both to canonical physics treatments of energy and the ways that energy concepts are leveraged in biology and chemistry. We emphasize coordinating and reconciling multiple models and representations. http://nexusphysics.umd.edu

PST2B19: 5-5:45 p.m. Development of Board Games for Learning Energy

Poster – Youngseok Jhun, Seoul National University of Education, Seochogu seochodong 1650 Department of Science; Korea youngseok.jhun@gmail.com

Yeonjeong Yu, Siyoung Kim, Seoul National University of Education

As the energy problem has been a great challenge all around the world for decades, the importance of energy education for the youth has also increased. We know that adults cannot change their way of life if they didn't start changing in childhood. Nevertheless of the importance of the energy education, many efforts to teach students rational usage of energy have shown little effectiveness. They say that rational and logical approach in energy education cannot expect high achievement, so we have to introduce the strategy of informal science education even in formal classes. A board game can be a good idea to learn science concepts, to have a chance of thinking about the energy crisis, to guide the students into inquiry on the energy problem. We developed two board games that make the users learn about the energy based on the informal learning theory. We were to make the students understand the basic concepts, find evidences, argue each other, and decide by themselves due to the games. We'd like to share our findings in the procedure of developing the board game and in the application for small groups of students.

PST2B20: 5:45-6:30 p.m. Flipping Upper-Division Undergraduate Classes Using Pencasts

Poster – Kathryn E. Devine, The College of Idaho, Caldwell, ID 83605-9990; kdevine@collegeofidaho.edu

In "inverted" or "flipped" classroom formats, lectures are delivered in an online format and class time is spent on activities such as group problem solving, computational modeling, and discussion. Flipped classes are becoming increasingly prevalent in physics education. One of the struggles encountered in flipping upper-division physics courses is how to record and share lectures, which are traditionally done at a chalkboard. I used an Echo LiveScribe pen to create "Pencast" audio-enabled files that covered lecture material for my Theoretical Mechanics and Quantum Physics courses. The logistics of creating and using the lectures and a summary of students' feedback will be presented.

PST2B21: 5-5:45 p.m. "Tiered" iClicker Recitation Introductions and an Open-Ended Experiment

Poster – David B. Blasing, Purdue University, West Lafayette, IN 47907-2040; dblasing@purdue.edu*

Andrew Hirsch, Rebecca Lindell, Purdue University

Interactively engaging students can significantly help them understand key concepts [Hake 1998]. In PHYS 272 at Purdue University, we are experimenting with two methods of interactive engagement: introducing recitations with qualitative, "tiered," iClicker questions and an open-ended laboratory where the students set up their own experiment. A typical iClicker series has three to five questions and begins at a level where most students are confident in their answers. The series progresses to a point where most students have difficulty identifying the correct answer. Our goal is to demonstrate that these qualitative introductions coupled with quantitative collaborative work increases the student?s overall learning gain (measured by the Brief Electricity and Magnetism Assessment). Separately, we are piloting an open-ended laboratory. The goal is to uncover the identity of 10 common circuit elements concealed in identical black boxes. The students can conduct any experiment using any of the equipment in the laboratory.

*Sponsored by Professor Andrew Hirsch

References: R.R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* **66** (May 1996), 64?74.

C – PER Posters 2

PST2C01: 5-5:45 p.m. An Evaluation of the Japanese Translation of the Force Concept Inventory

Poster – Michi Ishimoto, Kochi University of Technology, Tosayamada-cho Kochi, Other 782-8502; ishimoto.michi@kochi-tech.ac.jp

This study assesses the Japanese translation of the Force Concept Inventory (abbreviated to FCIJ). Because of differences between the Japanese and English languages, as well as between the Japanese and American educational systems, it is important to assess the Japanese translation of the FCI, a test originally developed in English for American students. The data consist of the pre-test results of 350 students and the post-test results of 335 students, most of whom were first-year students at a mid-level engineering school between 2011 and 2012. The basic statistics and the classical test theory indices of the FCIJ indicate that its reliability and discrimination are adequate in assessing Japanese students' pre-concepts about motion. The pre-concepts assessed with the FCIJ are quite similar to those of American students, thereby supporting its validity.

PST2C02: 5:45-6:30 p.m. RIP FCI: A Psychometric Argument

Poster – Rebecca S. Lindell, Purdue University, West Lafayette, IN 47907; rlindell@purdue.edu

Originally developed by Hestenes, Wells and Swackhamer in 1992, the Force Concept Inventory (FCI) consists of 30 research-based conceptual multiple-choice questions. Over the last 20+ years, tens of thousands of physics instructors throughout the world have utilized the FCI as a way to evaluate the success of their instruction. The question now arises is the FCI still a valid instrument to use to evaluate physics instruction? In this poster, I will present a psychometric argument attempting to answer this question. Alternative procedures will also be discussed.

PST2C03: 5-5:45 p.m. Force Concept Inventory Clarifications

Poster – Matthew R. Semak, University of Northern Colorado, Greeley, CO 80639; matthew.semak@unco.edu

Wendy K. Adams, Richard D. Dietz, University of Northern Colorado

Over the past two years we have conducted three iterations of think-aloud interviews with students as they grappled with questions on the Force Concept Inventory (FCI). Doing so has shown us that the difficulties they have with some questions have nothing to do with their understanding of physics. These difficulties involve diagrams, notations, and vocabulary that make perfect sense to physics teachers but can easily confuse beginning students. Informed by those think-aloud interviews, we modified a subset of questions to improve clarity. Also, for the same purpose, some new questions were added. Modifications were made after each round of interviews, and then the latest version of the clarified FCI was administered to students in two introductory physics courses. Here we present an overview of our efforts by discussing some specific changes made and how students responded to them.

PST2C04: 5:45-6:30 p.m. Developing a Survey of Thermody namic Processes and First and Second Laws*

Poster – Benjamin R. Brown, University of Pittsburgh, 100 Allen Hall, Pittsburgh, PA 15260; brb10@pitt.edu

Chandralekha 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.

*Supported by the National Science Foundation

PST2C05: 5-5:45 p.m. Developing and Evaluating Quantum Mechanics Formalism and Postulates Survey*

Poster – Emily M. Marshman, University of Pittsburgh, Department of Physics and Astronomy, 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

PST2C06: 5:45-6:30 p.m. Developing Static Fluids Assessment: Limiting the Number of Conceptions Probed

Poster – Doris Jeanne Wagner, Grove City College, 100 Campus Drive, Grove City, PA 16127; djwagner@gcc.edu

We are developing an FCI-style assessment covering hydrostatic topics commonly included in introductory physics courses. This past academic year we took a step back and gave a "fluids conception" Likert-style survey at many institutions, to try to narrow the range of conceptions targeted by our final assessment to the most prevalent ones. This poster will present commonly and uncommonly held misconceptions and plans for the future of the assessment. We're particularly interested in receiving suggestions from other educators and in recruiting more beta-testers. Stop by and chat!

PST2C07: 5-5:45 p.m. Evaluating the Effects of Course Style on Learning About Energy & Environment

Poster – Rebecca J. Rosenblatt, Illinois State University, Bloomington, IL 61701; rosenblatt.rebecca@gmail.com

We will present an ongoing project to design an assessment of content learning and attitude changes for different versions of an energy and environment physics course. The course is an examination of the scientific, environmental, economic, ethical, and political aspects of energy production and use. The course is taught in three ways: more traditional, flipped with active-group engagement, and online. We will present the methods we are using to build an assessment for these different course types. Also, we will present several specific findings about student understanding and reasoning within the topic of energy/environment. For example, we will discuss students' ability to support their ideas about global climate change with data and to compare energy footprints for different activities like walking a mile vs. using a computer for 20 minutes. Lastly, we will discuss their responses to attitude survey questions similar to some of those on the CLASS.

PST2C08: 5:45-6:30 p.m. The Multiple Roles of Assessment: Rubric Design in the Upper Division

Poster – Leanne Doughty, Michigan State University, East Lansing, MI 48824; leanne.doughty2@mail.dcu.ie

Steven J. Pollock, University of Colorado Boulder

Marcos D. Caballero, Michigan State University

End-of-course assessments play informative and evaluative roles in the ongoing attempt to improve instruction in our undergraduate physics courses: (i) Analysis of students' answers to assessment items provides insight into difficulties students experience with specific concepts and required skills; (ii) Comparison of students' performance on assessments before and after instruction gives a measure of student learning. While open-ended questions provide information about student reasoning (i), training graders to score students' answers to these type of questions so that meaningful comparisons can be made (ii) requires significant investment. One solution for reliable analysis of an open-ended assessment for both purposes is the use of a grading rubric that separates assessing student work and uncovering student difficulties. We have constructed a separable rubric for the Colorado Classical Mechanics/Math Methods Instrument that can be used by untrained graders to reliably score the assessment (i) and by others to unpack common student difficulties (ii).

PST2C09: 5-5:45 p.m. Learning Objectives Based Assessment in a University Physics Course

Poster – Todd Zimmerman, University of Wisconsin-Stout, E Menomonie, WI 54751; zimmermant@uwstout.edu

Learning Objectives Based Assessment (LOBA) is a type of standards-referenced grading. Performance of students in a LOBA university physics course is compared to students in a traditional points-based course. Comparisons include FCI scores, problem solving ability, and student study habits.

PST2C10: 5:45-6:30 p.m. Research-based Assessment Resources to Improve Teaching in Your Classroom and Department

Poster – Sarah B. McKagan, American Association of Physics, College Park, MD 20740-3845; smckagan@aapt.org

Adrian Madsen, American Association of Physics Teachers

Eleanor C. Sayre, Kansas State University

Often physics faculty want to know how their students are doing compared to other "students like mine." As part of the PER User's Guide (http://perusersguide.org), we are developing a national database of research validated assessment results and an accompanying data explorer. Here faculty can securely upload their students' anonymized assessment results and compare them to students from peer institutions and the national dataset, view a question-by-question breakdown and compare results over time. "One-click analysis" allows faculty members to visualize their data, view statistics, and download a report of the results. Results can be used to improve teaching, to make a case for more resources, for accreditation reports, or for promotion and tenure. Additionally, we are developing guides to these research validated assessments and access to the tests themselves. We will showcase our new online system and provide information about how you can use it.

PST2C12: 5:45-6:30 p.m. Raising Calculus to the Surface: Discovering Geometry Using Tangible Models

Poster – Aaron Wangberg, Winona State University, 322 Gildemeister Hall, Winona, MN 55987; awangberg@winona.edu

Eric Weber, Oregon State University

Brian Fisher, Pepperdine University

Jason Samuels, City University of New York - BMCC

The solutions to mathematics and science problems with multiple variables often rely upon the geometric relationships between mathematical objects. For most calculus and physics students, this geometric reasoning occurs after their algebraic understandings—if at all! This poster shows a new approach to multivariable calculus which lets students discover the geometric properties of mathematical objects before introduction with algebraic expressions. As a result, students are able to discuss the geometric (including coordinate dependent and independent) properties of such concepts as gradient, directional derivatives, level curves, integrals, and partial derivatives. Come explore how these physical surfaces help students bring their geometric knowledge of calculus to the surface and discuss how these tools could help physics students explore important quantities in physics.

PST2C13: 5-5:45 p.m. Evolution of C3PO: Customizable Computer Coaches for Physics Online

Poster – Qing X Ryan, University of Colorado, Boulder, 390 UCB, Boulder, CO 80309; xuqing12357@gmail.com

Evan Frodermann, Kenneth Heller, Leonardo Hsu, University of Minnesota-Twin Cities

Andrew Mason, University of Central Arkansas

The University of Minnesota Physics Education Research Group has been developing Customizable Computer Coaches for Physics Online (C3PO), a web-based system designed to help students progress toward expert-like problem solving in an introductory physics class. This poster describes the coaching system, the design process, and the evolution of the system as a result of extensive testing and feedback. This work was partially supported by NSF DUE-0715615 and DUE-1226197. Others who also contributed: Bijaya Aryal (University of Minnesota--Rochester), Kristy Crouse (University of Minnesota--Twin cities)

PST2C14: 5:45-6:30 p.m. Assessment of C3PO: Customizable Computer Coaches for Physics Online

Poster – Evan Frodermann, University of Minnesota-Twin Cities, Minneapolis, MN 55455-0213; frodermann@physics.umn.edu

Kristin Crouse Kenneth Heller, Leon Hsu, University of Minnesota-Twin Cities

Qing Ryan, University of Colorado-Boulder

The University of Minnesota Physics Education Research Group has been investigating the utility of using computer coaches to help students learn more expert-like problem solving skills in introductory physics. These coaches, Customizable Computer Coaches for Physics Online (C3PO), comprise a web-based system that allows students to follow their own path in solving a physics problem while providing them with guidance and feedback. This poster describes the measures of the effectiveness and utility of the coaches that were used in the environment of a large introductory physics class where many other factors influence their learning. B. Aryal, and A. Mason also contributed to this poster. This work was partially supported by NSF DUE-0715615 and DUE-1226197.

PST2C15: 5-5:45 p.m. Future of C3PO: Customizable Computer Coaches for Physics Online*

Poster – Jie Yang, University of Minnesota-Twin Cities, Minneapolis, MN 55455-0213; yang1999@umn.edu

Kristin Crouse, Evan Frodermann, Ken Heller, Leon, Hsu University of Minnesota-Twin Cities

Q. Ryan, University of Colorado Boulder

B. Aryal, UMN-Rochester

A. Mason, University of Central Arkansas

Based on the success of the first version of our computer coaches for solving problems in introductory physics, the University of Minnesota Physics Education Research Group has been developing its second generation, Customizable Computer Coaches for Physics Online (C3PO). In this poster, we describe the lessons learned from testing the first version of the coaches with hundreds of students and how the results impact the second version of the system.

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

PST2C16: 5:45-6:30 p.m. Computer Coaches for Problem Solving: Algebra-based Applications

Poster – Cassandra Lange, University of Central Arkansas, Lewis Science Center 171, Conway, AR 72035-0001; clange1@uca.edu

Andrew Mason, University of Central Arkansas

An introductory physics problem-solving framework is desirable for students to develop problem-solving skills. However, a potential obstacle to developing this framework, even with an explicit intervention, is with regard to student attitudes and approaches to problem solving. Computer coaches, developed at the University of Minnesota for introducing a problem-solving framework, are examined with respect to data taken from a reflection activity performed by students in an introductory physics for life science (IPLS) course. The activity consisted of students working on a problem in lab groups and recording aspects of the problem solving process in which they struggled. These recorded struggles are compared to the computer coaches' different problem solving steps.

PST2C17: 5-5:45 p.m. Explaining Student Perceptions of Interactive Video Vignettes in Undergraduate Physics

Poster – Jonathan A. Engelman, Kettering College, Kettering, OH 45429-1299; jonathan.engelman@kc.edu

Kathy Koenig, University of Cincinnati

Students in an entry-level undergraduate physics course engaged in short Interactive Video Vignettes (IVVs) outside of class in order to enrich their understanding of specific physics concepts. Prior work by the LivePhoto Physics Group suggests that students enjoy using IVVs and that their use does improve learning, but not to the same extent for every IVV. The research question for this study is: What characteristics of Interactive Video Vignettes help or hinder student learning in introductory physics courses? The purpose of this explanatory sequential mixed methods study (Creswell & Plano Clark, 2011) is to begin explaining the thoughts, opinions, and perceptions regarding the use of IVVs for roughly 15 students in an entry-level undergraduate physics course. This poster reports the results of a survey given to students during the course, interviews conducted after the course, and integration of these data. Supported by NSF grants DUE-1122828 and DUE-1123118.

PST2C18: 5:45-6:30 p.m. Describing Video Viewing Behavior in a Flipped Introductory Mechanics Course

Poster – John M. Aiken, Georgia Institute of Technology, Atlanta, GA 30332; johnm.aiken@gmail.com

Shih-Yin Lin, Scott S. Douglas, Edwin F. Greco, Michael F. Schatz, Georgia Institute of Technology

Brian D. Thoms, Georgia State University

Marcos D. Caballero, Michigan State University

In Fall 2013, Georgia Tech began offering a "flipped" introductory calculus-based mechanics class as an alternative to the traditional large enrollment lecture class. This class "flips" instruction by introducing new material outside of the classroom through pre-recorded, lecture videos that feature in-video "clicker" questions. Classroom time is spent working in small groups solving problems, practicing scientific communication, and peer evaluation. Video lectures constitute students' initial introduction to course material. We analyze how students engage with online lecture videos via "clickstream" data. Clickstream data consists of time-stamped interactions with the online video player. Plays, pauses, seeks, and other events are recorded when the student interacts with the video player. Patterns in this behavior can emerge and be used to highlight areas of interest in the video and improve the overall video delivery for future iterations of this course.

PST2C19: 5-5:45 p.m. Conceptual Versus Computational Homework

Poster – Kristi D. Concannon, King's College, Wilkes Barre, PA 18711; kristiconcannon@kings.edu

Does the type of homework assigned in an introductory physics course affect exam performance? In spring 2014, two sections of algebra-based second-semester introductory physics were taught by the same instructor. Class-time for both sections focused primarily on building conceptual understanding, with minor emphasis on the mechanics of problem solving. End-of-chapter problems were assigned to each of the two sections: Section A was assigned 8-10 conceptual exercises; Section B was assigned 2-3 computational problems. The alternate problem sets were recommended to students, but were not collected for grading. Three exams and a comprehensive final exam were given, each evenly weighted with conceptual and computational problems. We anticipated that (1) students in the section requiring conceptual homework would perform better on conceptual exam questions than students required to submit computational homework and (2) students in both sections would perform equally well on the computational exam problems. This poster will present our findings.

PST2C20: 5:45-6:30 p.m. Examining Epistemological Beliefs in Undergraduate Thesis Writing

Poster – Jason E. Dowd, Duke University, Durham, NC 27708; jason.dowd@duke.edu

Julie A. Reynolds, Robert J.Thompson, Duke University

We present results from ongoing research to better understand how writing an undergraduate thesis improves scientific reasoning and writing skills through impacting metacognition, motivation, and epistemological beliefs. Previous work indicates that scaffolding the writing process in a thesis-writing course can be an effective strategy for promoting better writing and stronger scientific reasoning skills. Our findings suggest that students' beliefs about the nature of knowledge are, indeed, related to students' exhibition of these skills. Here we further explore this relationship through analysis of the coherence of students' various epistemological beliefs and the effect of epistemology-focused classroom interventions on learning outcomes. Data have been collected across multiple departments and institutions over two years. Ultimately, our analysis will be used to shape continued institution- and department-specific changes during subsequent years of this multi-year study.

PST2C21: 5-5:45 p.m. Examples of Whole Class "Board" Meetings Overcoming Sharp Initial Disagreements

Poster – Brant E. Hinrichs, Drury University, Springfield, MO 65802; bhinrichs@drury.edu

This poster describes a whole-class whiteboard meeting and gives three examples of how they are used in a calculus-based introductory physics course taught using modeling instruction. Students in one section are divided into six groups of 4-5 students each. Each group creates a solution to the same problem on a 2 x 3' whiteboard. The groups then form a large circle in the center of the classroom with their whiteboards on the ground, resting against their knees, facing out to the rest of the group. The instructor is outside the circle and interjects only rarely, if at all. The goal of the discussion is to come to a consensus on the "best" answer to the given problem. Three examples are given of amazing conversations where students overcome sharp initial disagreements to eventually reach whole-class consensus. Students are learning the epistemology of science by actively engaging in it every class.

PST2C22: 5:45-6:30 p.m. Truly Interactive Use of Interactive Whiteboards in High School Physics

Poster – Bor Gregorcic, University of Ljubljana, Jadranska 19 Ljubljana, SI: 1000 Slovenia; bor.gregorcic@fmf.uni-lj.si

Eugenia Etkina, Rutgers University

Gorazd Planinsic, University of Ljubljana

In a pilot study we did last year in a Slovenian high school, we have found that IWBs are not being used to their full potential, as physics teachers are mostly not taking advantage of the interactive affordances of the touch-sensitive surface. As a continuation of the study, we have designed two lessons that incorporate students' creative graphical and kinaesthetic input as a key part of the learning sequence. Two teachers, although experienced users of the IWB, learned to work with the IWB in a new way and implemented the designed lessons in their classes. One of the teachers also participated in the design process and analysis of one lesson, which gave us valuable critical feedback on our ideas. The study investigates how teachers and students responded to the novel approach to IWB use and how it influenced the classroom dynamics.

PST2C23: 5-5:45 p.m. How Do Course Materials Address Students' Learning Difficulties?

Poster – Ozden Sengul, 25 Park Place, Room 605, Atlanta, GA 30303; Atlanta, GA 30303 osengul1@student.gsu.edu

Laura Kiepura, Joshua Von Korff, Georgia State University

At Georgia State University, we are participating in a collaborative research study starting in fall 2014 with two other universities, GW and UCF, to explore the successful instructional strategies for the implementation of studio physics in the algebra-based introductory physics classes. As part of this study, we have collected course documents to investigate differences in how various instructors frame their assignments. Course documents, such as in-class activities, quizzes, and experiments, have significant importance in teaching-learning and affect students' learning and instructors' teaching processes. Therefore, we propose to analyze course documents, which are used in studio classes at different institutions. The analysis will be built on students' intuitive ideas grounded in everyday experiences and basic scientific conceptions; we will examine how the activities or homework are used to address students' learning difficulties with regard to certain scientific conceptions.

PST2C24: 5:45-6:30 p.m. How Does Problem-solving Training Affect Students' Reasoning Patterns?*

Poster – Xian Wu, Kansas State University, Manhattan, KS 66506; xian@phys.ksu.edu

Elise Agra, Claudia Fracchiolla, N. Sanjay Rebello, Kansas State University

We study the effects of a computer-based training process on pre-service elementary teachers' reasoning. There are four introductory physics problem sets with diagrams in our training process. Each problem set has three training problems with solutions followed by one near transfer problem and one far transfer problem. All of the problems are based on physics diagrams and conceptual understanding rather than calculations. The entire training processes have been video and audio recorded. We analyze students' verbal answers in order to unravel the reasoning resources that they activated to construct the different explanations given. We found that student reasoning patterns have been changed dramatically throughout this process. Our results provide insight into student activation of their resources and the procedures they facilitated to construct their understanding by walking through the training problems and solutions.

*This material is based upon work supported by the National Science Foundation under Grant No. 1138697 and 1348857.

PST2C25: 5-5:45 p.m. Simulating Nanoscale Magnetism as a Single Domain

Poster – David Sederberg, Purdue University, West Lafayette, IN 47907; dsederbe@purdue.edu

Jeffrey Wozniak, Purdue University

High school and even undergraduate student's explanations of magnetic phenomena seldom involve the dynamic alignment of fundamental structural components, their individual contribution to net forces, reversibility, and effects of applied fields. These concepts carry special meaning with respect to the size dependency of ferromagnetic materials at the nanoscale where, as consequence of ambient thermal energy, materials can exhibit zero remanence. In an interactive computer simulation of a single domain ferromagnetic particle, students manipulate three variables: size, applied field, and temperature. Initial piloting in both middle and high school settings suggests that the immediate feedback depicting the magnetic moments of the atoms on the surface of the domain, relative to those comprising the whole, provided a framework with which students could interpret the effect of each of the variables, individually or in concert on overall magnetic moment and remanence. Opportunities are sought for additional field testing of the simulation module.

PST2C26: 5:45-6:30 p.m. Implementing Lecture-Tutorial Exercises in an Introductory Astronomy Course

Poster – Eric A. Williams, Florida International University, 11200 SW 8th St., Miami, FL 33199; ewill085@fiu.edu

Caroline E. Simpson, Florida International University

We present initial results from a study on the effects of pedagogical course reform in two sections of an introductory astronomy course for non-science majors at Florida International University. This reform was accomplished by implementing publisher-supplied hands-on lecture tutorials (LTs), which are short (15-30 minute) workbook activities that are done in class in small groups. Each LT is designed so that students uncover and confront common misconceptions about astronomical and physical concepts. The instructor, with the help of undergraduate learning assistants, acts as a facilitator during each LT exercise. Here we discuss the methods and challenges of implementation, and the impact on student learning by comparing exam performance in the LT sections to that in traditionally taught lecture sections.

PST2C27: 5-5:45 p.m. Improving Students' Understanding of Gauss's Law*

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

Jing Li, University of Pittsburgh

We discuss the development and assessment of research-based tutorials on helping students learn about symmetry and Gauss's law. We discuss the performance of students on the pre-/post-tests given before and after the tutorials in several calculus-based introductory physics courses. We also compare the performance of students who used the tutorials with those who did not use them. We thank the National Science Foundation for support.

*We thank the National Science Foundation for support.

PST2C28: 5:45-6:30 p.m. Improving Students' Understanding of Lock-In Amplifiers*

Poster – Seth T. DeVore, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260-3583; std23@pitt.edu

Alexandre Gauthier, Jeremy Levy, Chandralekha Singh, Department of Physics and Astronomy, 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.

PST2C29: 5-5:45 p.m. Quantum Interactive Learning Tutorial (QuILT) on Quantum Key Distribution*

Poster – Seth T. DeVore, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260-3583 std23@pitt.edu

Chandralekha Singh, University of Pittsburgh

We have been conducting research and developing and assessing a quantum interactive learning tutorial (QuILT) on quantum key distribution to expose students to contemporary and exciting 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 using single photons with non-orthogonal polarization states and 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

PST2C30: 5:45-6:30 p.m. Learning Introductory Physics via Web-based Tutorials and Scaffolded Prequizzes*

Poster – Seth T. DeVore, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260-3583 std23@pitt.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 pre-quizzes 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 pre-quizzes and weigh on the strengths and weaknesses of each intervention.

*We thank the National Science Foundation for support.

PST2C31: 5-5:45 p.m. Quantum Interactive Learning Tutorial (QuILT) on Mach Zehnder Interferometer with Single Photons*

Poster – Emily M. Marshman, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260 emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We are developing and assessing a quantum interactive learning tutorial (QuILT) on Mach Zehnder Interferometry with single photons to expose students to contemporary applications of quantum mechanics. The QuILT strives to help students develop the ability to apply quantum principles in physical situations, explore differences between classical and quantum ideas, and organize knowledge hierarchically. The QuILT also helps students learn about delayed choice experiments, first proposed by John Wheeler. The QuILT adapts visualization tools to help students build physical intuition about non-intuitive quantum phenomena and focuses on helping them integrate qualitative and quantitative understanding and discriminate between concepts that are often confused. Details of the development and assessment will be discussed.

*This work is supported by the National Science Foundation.

PST2C32: 5:45-6:30 p.m. Quantum Interactive Learning Tutorial (QuILT) on Quantum Eraser*

Poster – Emily M. Marshman, University of Pittsburgh, Department of Physics and Astronomy, Pittsburgh, PA 15260; emm101@pitt.edu

Chandralekha Singh, University of Pittsburgh

We are developing and assessing a quantum interactive learning tutorial (QuILT) on quantum erasure. The quantum eraser apparatus uses a Mach Zehnder Interferometer with single photons and exposes students to contemporary applications of quantum mechanics. The QuILT strives to help students develop the ability to apply quantum principles in physical situations, explore differences between classical and quantum ideas, and organize knowledge hierarchically. The QuILTs adapt existing visualization tools to help students build physical intuition about non-intuitive quantum phenomena. Details of the development and assessment will be discussed.

*This work is supported by the National Science Foundation.

PST2C33: 5-5:45 p.m. Promoting Self-regulated Learning in Introductory Mechanics

Poster – Jeffrey A. Phillips, Loyola Marymount University, Los Angeles, CA 90045; jphillips@lmu.edu

Students who successfully engage in self-regulated learning, are able to plan their own studying, monitoring their progress and make any necessary adjustments based upon the data and feedback they gather. In order to promote this type of independent learning, a recent introductory mechanics course was modified such that the homework and tests emphasized the planning, monitoring and adjusting of self-regulated learning. Students were able to choose many of their own out-of-class learning activities. Rather than collecting daily or weekly problem set solutions, assignments were mostly progress reports where students reported which activities they had attempted, self-assessment of their progress, and plans for their next study session. Tests included wrappers where students were asked to reflect on their mistakes and plans for improvement. While many students only engaged superficially the independent aspects of the course, some did demonstrate evidence of self-regulation. Examples of student work will be presented.

PST2C34: 5:45-6:30 p.m. Implementing and Evaluating Peer-review of Writing for Freshmen Engineers

Poster – Kathleen A. Harper, Engineering Education Innovation Center, The Ohio State University, Columbus, OH 43210; harper.217;@osu.edu

One goal of the Fundamentals of Engineering for Honors sequence at The Ohio State University is to develop strong technical communication skills. As part of a "cornerstone" design-and-build robotics project for second-semester engineering majors, teams write a thorough technical report. During the nearly 20-year history of the program, teams have submitted drafts of each half of the report for feedback. In spite of the heavy emphasis on technical writing in the prior semester, these drafts have often been disappointing and time-consuming to grade. Also, it sometimes has seemed that feedback on the first half draft had little impact on the quality of the second half draft. To address these weaknesses, teams now draft the first two sections of their report earlier in the term for a peer review and feedback exercise. This talk describes the details of the exercise, along with an assessment of its effectiveness.

PST2C35: 5-5:45 p.m. Peer Evaluations vs. Instructor Evaluations of Student Lab Reports

Poster – Shih-Yin Lin, 837 State St., Atlanta, GA 30332-0002; hellosilpn@gmail.com

Scott S. Douglas, John M. Aiken, Edwin F. Greco, Michael F. Schatz, Brian D. Thoms, Georgia Institute of Technology

Marcos D. Caballero, Michigan State University

As part of an introductory physics course offered at Georgia Tech, students submit video reports on force and motion labs. Peer grading of reports provides the primary method for evaluating student laboratory work. During peer grading, students are guided to rate each others' videos on a rubric consisting of several likert-scale questions. They are also encouraged to provide written feedback explaining their grading for each rubric item. This paper explores how peer evaluations compare to instructors evaluations by examining the likert-scale responses and written responses provide by both students and instructors. The written responses will be coded to understand what students and instructors attend to in their grading. Similarities and differences between student grading and expert grading will be discussed

PST2C36: 5:45-6:30 p.m. Improving Conceptual Understanding in Physics Class for Non-traditional Students

Poster – Olga A. Stafford, South Dakota State University, Brookings, SD 57006; olga.stafford@sdstate.edu

A different teaching approach has to be used in physics class for nontraditional students. Most of them have limited free time to study and little math preparation for taking the class. In order to improve students' conceptual understanding of physics concepts a few teaching technics might be used. They are: studio format teaching style, group work in groups with traditional students, initiation of discussion during the lecture class, recitation and Lab right after learning material in class, mostly studying in class with weekly online homework and chapter's reading quizzes. Students' gain in conceptual understanding of physics principles significantly improved based on results of standard pre- and post- test in comparison with the national data.

PST2C37: 5-5:45 p.m. Student Journeys for Understanding Radiation and Radioactivity*

Poster – Andy P. Johnson, Black Hills State University, 1200 University, CAMSE, unit 9005, Spearfish, SD 57783; andy.johnson@bhsu.edu

Anna Hafele, Ryan Anderson, BHSU

Radiation literacy is a key component of scientific literacy. However, few people understand much about radiation. Most people think radiation can spread to and contaminate objects and organisms, making the victims radioactive and causing mutations. People tend to use the terms "radiation" and "radioactivity" interchangeably. These alternate ideas impede learning and reasoning about radiation and radioactivity. The research presented in this poster shows that developing understandings of radiation is a slow process that occurs gradually and that seems to require a well-structured environment. Thus it appears that teaching radiation will only result in meaningful understanding when the teaching effort is sustained and robust. We present evidence for some of the stages in students gradually progressing to understanding radiation.

*This research, which is part of the Inquiry into Radioactivity (IiR) project, is supported by NSF DUE grant 0942699.

PST2C38: 5:45-6:30 p.m. Solving the Two Sigma Problem

Poster – Wendy K. Adams, University of Northern Colorado, Department of Physics and Astronomy, Greeley, CO 80639; wendy.adams@unco.edu

Connor Jordan, University of Northern Colorado

We have developed a course for students with weak backgrounds in physics that has consistently resulted in an effect size over three for female students and over two for males on the Force Concept Inventory. This course demonstrates improved outcomes in three areas that have not been previously reported in the literature: a) very large effect sizes on a concept tests, b) reasonable FCI gains (0.57) using interactive engagement with poorly prepared students, and c) reducing the gender gap. The course is structured around the theoretical design of engaging students in effortful practice via a highly structured course with lots of feedback. The structure is provided to block student short cuts. Groups and activities have been carefully chosen to provide a safe environment for discussion and practice, and the idea that effort results in success is constantly reinforced by activities with reasonable challenges.

PST2C39: 5-5:45 p.m. Student Perspectives and Reflections on Project-based Pedagogies

Poster – Kristina Ward, Creighton University, Omaha, NE 68178; KristinaWard@creighton.edu

Gintaras K. Duda, Creighton University

This poster will present the results of student interviews and student reflections from several project-based learning (PBL) courses at Creighton, including an upper-division quantum mechanics course and a freshman-level integrated calculus and physics course. The PBL courses will be described and common themes will be presented and discussed, such as motivation, changes in students' epistemologies, and teaming issues. Student suggestions for more successful implementations of PBL pedagogies will also be discussed.

PST2C40: 5:45-6:30 p.m. Measuring the Effectiveness of Collaborative Group Exams

Poster – Joss Ives, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada; joss@phas.ubc.ca

I will report on the results of a study designed to measure the effectiveness of an instructional strategy known as 2-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 featured different subsets of the questions from the individual exam. Questions isomorphic to the exam questions will be administered on the end-of-course diagnostic and comparisons, using the relevant isomorphic question, will be made between the students that saw a given question on the group exam and those that did not.

PST2C41: 5-5:45 p.m. Implementing Elaborative Interrogation in an Introductory Physics Course

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

Eugenia Etkina, Rutgers University

Elaborative Interrogation, a comprehension strategy that asks students to read a passage from the text and respond to the prompt "Why is this true?" for a sentence from the passage, was employed in an introductory college physics course. In this poster, initial results with regard to student accuracy and depth of reasoning are reported, and the effect of sentence type on student responses is detailed. A reading survey was also conducted to address students' reading habits during the course. Results from the reading survey indicate that students read more when asked to complete the interrogation questions as compared to when they are just asked to read the text.

PST2C42: 5:45-6:30 p.m. Facilitating Students' Transfer of Learning Through Integration of Interdisciplinary Contexts

Poster – Bijaya Aryal, University of Minnesota-Rochester, 300 University Square, Rochester, MN 55904; baryal@umn.edu

Robert L. Dunbar, Rajeev S. Muthyala, Starr K. Sage, University of Minnesota-Rochester

We designed a module-based learning cycle for an introductory-level physics course integrating interdisciplinary contexts. A multi-disciplinary group of faculty contributed to the development of various teaching activities involving multiple contexts. Students were expected to learn physics concepts and skills, and then apply the learning in various interdisciplinary contexts in the last stage of the learning cycle. We define such application of concepts and skills across contexts as transfer of learning. In this presentation we report on the design, implementation and assessment of students' learning of physics in the learning environment. We also describe the extent and nature of students' ability to transfer physics in various contexts. Moreover, we present the impact of presentation of interdisciplinary contexts by instructors of different disciplines on transfer tasks and we provide results of our comparative study on students' spontaneous transfer of physics learning to contexts involving science courses and non-science courses.

PST2C43: 5-5:45 p.m. Impact Video Tracker in the Teaching of Physics for Engineers

Poster – Oscar Jardey, OJS Suarez Fundación Universidad Autónoma de Colombia, Calle 13 No 4 - 21 Bogotá, AA 11001 Colombia; sistemas29@hotmail.com

This poster aims to socialize a classroom experience and its impact on the teaching of translational kinematics in the first courses of physics for engineers. The experience is based on an epistemological approach of the experiment in engineering education, supported by didactic sequences as a set of activities with defined intentions. Methodologically based on an experiment, traditionally a block sliding down an inclined plane (air table), focus in comparing the results recorded by a PASCO sensor, manual records, and records of video tracker, information is processed in the spreadsheet with the above is written and exposes an article. The "learning achievement" is measured and compared in two student groups—one control and other experimental. The results show significant differences in the writing, speaking, and conceptual organization.

PST2C44: 5:45-6:30 p.m. Exploring the Gender Gap in an Algebra-based Physics Course

Poster – Twanelle W. Majors, Tennessee Technological University, Cookeville, TN 38505-0001; twanellemajors@yahoo.com*

Paula V. Engelhardt, Tennessee Technological University

The differences in performance of males and females in physics have been well documented. While evaluating the effectiveness of the Learner-centered Environment for Algebra-based Physics curriculum (LEAP), results on the Force Concept Inventory for the first semester course showed that females in LEAP sections perform the same as males in traditional sections, which suggests that the LEAP curriculum might be effective in reducing the performance gap between males and females. To better understand whether this result is due to pedagogical or assessment choices, students in the LEAP and traditional course sections were given the Gender FCI developed by Laura McCullough which replaces the school/male-oriented contexts with real-life/female-oriented contexts. Propensity scoring was used to strengthen the findings as confounding variables can have a significant effect on estimating the effect of the curriculum. The results from this work will be presented in this poster.

*Sponsored by Paula V. Engelhardt

D – Outreach and Informal Physics

PST2D01: 5-5:45 p.m. Impact of Informal Physics Activities on Student Interest in STEM

Poster – Michele McColgan, Siena College, School of Science, Loudonville, NY 12211; mmccolgan@siena.edu

Albert Andrade, Siena College

The Siena Saturday Seminars for Urban Scholars After-school Program provides opportunities for underserved urban youth to engage in a wide range of informal, yet authentic, real-world science, technology, engineering, art, and math projects. This poster will present the results of several surveys given to students to determine student interest in science generally and in physics topics specifically after participating in Siena's urban scholars 14-week program.

PST2D02: 5:45-6:30 p.m. The Analysis of Pupils' Activities in Children's Science Museum with an Aspect of Stimulating, Finding, and Fostering their Talents

Poster – Seo Bin Park, Seoul National University of Education, jungrang-gu shinnae2-dong keumkang livingstel 407 Seoul, 0 131-872; jinakr@sen.go.kr

The importance of a science museum keeps increasing as an institute of informal science education. We have focused the role of the children's science museum to help pupils learn science without verbal, logical, and mathematical approach. We believe that the museum can stimulate, find, and foster the various talents with which children are born. With that background, we observed the children's activities to match the exhibits and talents they stimulate. As a consequence of the research, we are to suggest the direction of exhibition in children's science museum that can satisfy all the children with different intelligent profiles.

PST2D03: 5-5:45 p.m. History of the NJAAPT Physics Olympics

Poster – David P. Maiullo, Rutgers University, 136 Frelinghuysen Road, Piscataway, NJ 08854-8019; maiullo@physics.rutgers.edu

The New Jersey Section of the AAPT has a long history of organizing a successful Physics Olympics event for high schools in New Jersey. This event was held once per year and had many schools across NJ participating in it. The poster will detail the history, many of the events, a listing of the winners, and many of the individuals who were responsible for the event's success, and evolution through the years.

PST2D04: 5:45-6:30 p.m. Student Models of Weather, Climate, and Climate Change

Poster – Jignesh Mehta, Purdue University, West Lafayette, IN 47907; jmehta@purdue.edu

Anita Roychoudhury, Andrew Hirsch, Daniel Shepardson, Purdue University

Climate change is an important challenge of our time but public understanding of it is limited at best. Newly released Next Generation Science Standards (2013) suggests that climate change be taught from the middle school level onward. We think that teaching of this complex topic needs to begin with what students know about weather, climate, climate change, and global warming. This exploration of student understanding needs to be done at the level where climate change education is expected to begin. To meet this need, we explored middle school students' responses to open-ended questions and constructed student models of these concepts. These models have implications for curriculum development and instruction at the secondary (7-12) grades.

PST2D05: 5-5:45 p.m. Physics and Having Fun: The Trebuchet

Poster – Joel C. Berlinghieri, The Citadel, Physics Department, Grimsley Hall, Charleston, SC 29409; berlinghieri@citadel.edu

The trebuchet is a siege engine that was developed in medieval times before the laws of classical mechanics were developed. Yet the trebuchet is a marvel of efficiency in converting potential energy into kinetic energy and launching a projectile at the most optimum angle. Each year The Citadel organizes a trebuchet contest involving kindergarten, elementary and middle school, high school and college, and corporate divisions. The teams compete within their division for projectile accuracy and distance, and for team spirit (Medieval dress). There is also an advanced, invitation-only Barbarian division for very large trebuchets. Trebuchet kits are supplied to the kindergarten and elementary school divisions and financial support to the upper school divisions. Workshop sections for teachers and college and corporate teams are provided where the physics of the trebuchet is explained, each according to background and skills of the participants. Students, teachers, and other team members have fun building their trebuchet, measuring its efficiency, calibrating its adjustments for accuracy and precision, and enjoying a day of competition.

*For the past four years support has been provided by a grant from the Google Corporation.

PST2D06: 5:45-6:30 p.m. Give Peas a Chance: A Citizen Science Discovery

Poster – Miranda C P Straub, University of Minnesota, Minneapolis, MN 55455-0213; pihlaja@physics.umn.edu

The Zooniverse is a suite of online citizen science projects that has provided an opportunity for volunteers to contribute to science and humanities research without requiring extensive training or expertise. It uses crowd-sourcing methods to make independent classifications useful to researchers on the science teams. Since the launch of the first Zooniverse project in 2007, the organization has grown to more than 25 projects and reached the 1,000,000 participant mark in early 2014. While the goal of using volunteers for data processing has been successful, there have been unexpected examples of genuine discoveries by citizen scientists along the way. This talk will focus on the discovery of a class of galaxies called the "Green Peas," which were discovered by Galaxy Zoo volunteers in 2007. I will highlight elements of the scientific research process they used to characterize these as a new class of object, and explain identify common themes that can be used to encourage further serendipitous discoveries in other projects.

PST2D07: 5-5:45 p.m. Simulating and Stimulating the Social Production of Science Knowledge

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

Physics is at its most exciting when international teams are collaborating and competing to understand new ideas, but the social component of science has long been overlooked. Ford [1] suggests that constructivist approaches to science education fall short unless they pair model construction with appropriate critique. I attempt to bring these together in The Science Game, an extracurricular simulation of cutting-edge research. We asked students to investigate the properties of fat globules in milk, as seen under a microscope. The students developed knowledge claims based on Toulmin's Argument Patterns. [2] These claims, along with the data and warrant, were distributed and critiqued using symposia, pre-prints, a journal, and informal communication. I will give an overview of the students' work and evaluate the effectiveness of this approach for learning both knowledge and "grasp of practice".[1]

1. Michael Ford, "Disciplinary authority and accountability in scientific practice and learning," *Sci. Educ.* **92**.3 (2008), 404-423.

2. Sibel Erduran, Shirley Simon, and Jonathan Osborne, "TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse," *Sci. Educ.* **88**.6 (2004): 915-933.

E – Technology Posters

PST2E01: 5-5:45 p.m. What Can We Learn from Student Interactions with MasteringPhysics?

Poster– Marina Malysheva, Rutgers University, 2209 Sayre Dr., Princeton, NJ 08540; malyshev@eden.rutgers.edu

Michael Gentile, Eugenia Etkina, Rutgers University

Students in a reformed introductory physics course at Rutgers University work on their weekly homework assignments online, using a web-based learning environment (an interactive tutoring system MasteringPhysics). The system allows you to assign tasks of different types, and to provide different levels of scaffolding. For this study, we focused on a specific type of task, called a tutorial. The tutorials provide a high degree of support, leading students through a sequence of sub-tasks, and providing hints (if requested by the student), an immediate answer-specific feedback, and follow-up comments. The system collects data about student performance and student-system interaction. We report the results of our analysis of these data, and discuss the important lessons we have learned during the first year of using this system, and possible ways to use our results to improve the course.

PST2E02: 5:45-6:30 p.m. Learning Physics with MinecraftEDU

Poster – Michele McColgan, Siena College, Loudonville, NY 12211; mmccolgan@siena.edu

Minecraft is a popular sandbox game. Tutorials in MinecraftEDU allow students to quickly navigate, interact, and build within the game and learn the skills they need to participate in activities and lessons within the game. MinecraftEDU includes built-in tools to quickly create worlds for teachers to create a learning environment for students on different topics. As students become more proficient, comparisons between physics in the Minecraft world and the real world become obvious. Is there gravity in Minecraft? Sometimes! How fast does a player walk or run? Can you predict the flight of a projectile? Students can quickly build experiments in MinecraftEDU to answer these questions. This poster will present tools within MinecraftEDU that provide an opportunity for teachers to build lessons within the game and for students to explore different physics topics such as vectors, forces, momentum, circular motion, electric fields, magnetic fields, and so much more.

PST2E03: 5-5:45 p.m. Quality Education and Quality Entertainment at HarvardX

Poster – Colin M. Fredericks, Harvard, 42 Rawson Road, Arlington, MA 02474; colin.fredericks@gmail.com

In-classroom demonstrations and labs are great for hands-on experience, and a lot of fun for students. Online courses need their own equivalents, and there is no shortage of options. This poster presents some of the fun stuff we're building into our courses at HarvardX.

PST2E04: 5:45-6:30 p.m. The Effect of Online Lecture on Performance in a Physics Class

Poster – John C. Stewart, University of Arkansas, Physics Building, Fayetteville, AR 72701; johns@uark.edu

This poster will examine the difference in student performance between students attending lecture in person and students choosing to watch the lecture on video as part of an online class. The option to watch the lecture on video was implemented mid-semester in fall 2012 so that the performance of the same set of students could be compared. A fully online lecture section was introduced in spring 2013. Higher than expected withdrawal rates have been experienced in the online sections of the class. These will be examined in the context of the historical performance of the class, the demographics of the students, and their motivation for enrolling in the online experience. Differences in time-on-task for online and face-to-face students will also be presented.

PST2E05: 5-5:45 p.m. The Physics of Smart Phone Sensors

Poster – Al J. Adams, University of Arkansas at Little Rock, 2801 South University Ave., Little Rock, AR 72204-1099; ajadams@ualr.edu

Mobile devices today are powerful measurement systems and most of the onboard transducers are designed to measure the very parameters of interest to physicists and physics teachers. These include linear acceleration, angular velocity, magnetic field, light and sound levels, and imaging and video-recording capability. In order to use these portable measurement systems most effectively in a teaching environment it is important for those designing teaching and learning activities to understand the physics behind their operation and the nature of their electronic output. I have begun to research the design and operation of the sensors being used in smartphones. Much to my surprise the basic physics behind them can be found in most introductory physics texts; smartphone sensors provide a timely illustration of physics principles, one of immediate interest to our current student population.

PST2E06: 5:45-6:30 p.m. Tying Online Homework to the Book While Keeping Costs Down

Poster – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099; pawla@uwplatt.edu

Paradoxically, the publisher-managed homework systems that accompany textbooks are often constructed in a manner that actually discourages students from engaging with the book. They are also expensive and offer subscription models that do not always fit classroom logistics. In this poster, I describe an alternative to commercial packages that simultaneously ties the homework more closely to the book and lowers costs for the students. My approach is explicitly intermediate between buying the publisher's package and the "do-it-yourself" option of coding up all the homework. It does mean more work for me than when I was simply picking out problems from the commercial package, but it is far less difficult than writing a complete homework library of my own.

PST2E07: 5-5:45 p.m. Particle Physics Experiments for High School Using Medipix/Timepix

Poster – Jan Koupil, IEAP, Czech Technical University, Prague Horská 3a/22 Prague, 12800 Czech Republic; jan.koupil@gmail.com

Vladimír Vícha, IEAP, Czech Technical University

The Medipix/Timepix chip developed by CERN is usually being used in medical imaging, material analysis, optics or even in space programs. However, in a setup named Jablotron MX-10 it is ready for in-classroom use. Unlike traditional detectors like Geiger tubes, the pixel detector offers a real-time display, recognizes different particle types, and is able to show particle traces. This poster will present a set of high school experiments taking advantage of the chip abilities. Some examples of these experiments are "Showing the statistical nature of radioactive decay", "Studying absorption of different particle types in materials" or "Natural background radiation."

*Sponsored by Dr. Stanley Micklavzina

F – Upper Division and Graduate

PST2F02: 5:45-6:30 p.m. Comparing Alternate Approaches to Spacetime Diagrams

Poster – Roberto Salgado, University of Wisconsin La Crosse, 1725 State St., La Crosse, WI 54601; rsalgado@uwlax.edu

Tobias Nelson, University of Wisconsin La Crosse

We present a systematic survey of the various methods for drawing spacetime diagrams for special relativity. We study the Loedel, Brehme, Epstein, and Minkowski diagrams. By considering how each method handles some standard examples in Special Relativity, we identify the strengths and weaknesses of each approach.

PST2F03: 5-5:45 p.m. Legendre Transforms for Dummies

Poster – Carl E. Mungan, U.S. Naval Academy, Annapolis, MD 21402-1363; mungan@usna.edu

Legendre transforms appear in two places in a standard undergraduate physics curriculum: (1) in classical mechanics when one switches from Lagrangian to Hamiltonian dynamics, and (2) in thermodynamics to motivate the connection between the internal energy, enthalpy, and Gibbs and Helmholtz free energies. Both uses can be compactly motivated if the Legendre transform is properly understood. Unfortunately, that transform is often relegated to a footnote in a textbook, or worse is presented as a complicated mathematical procedure. In this poster, I simplify the idea to the point that the Legendre transform can be elegantly presented in class in a sensible and accessible manner. In a nutshell, a Legendre transform simply changes the independent variables in a function of two variables by application of the product rule.

PST2F04: 5:45-6:30 p.m. Ongoing Validation of an Upper-division Electrodynamics Conceptual Assessment Tool

Poster – Qing Xu Ryan, University of Colorado, Boulder, 390 UCB, Boulder, CO 80309; xuqing12357@gmail.com

Cecilia Astolfi, Charles Baily, University of St Andrews

Steven Pollock, University of Colorado, Boulder

As part of an ongoing project to investigate student learning in upper-division electrodynamics (E&M II), the PER research group at CU Boulder has developed a tool to assess student conceptual understanding (the CURrENT: Colorado UppeR-division ElectrodyNamics Test). This instrument is motivated in part by our faculty-consensus learning goals and can serve to measure the effectiveness of transformed pedagogy. In this poster, we present measures of the validity and reliability of the instrument and scoring rubric. These include expert validation and student interviews, inter-rater reliability measures, and classical test statistics. This work is supported by the University of Colorado and NSF-CCLI grant #1023208.

PST2F05: 5-5:45 p.m. Coupled Multiple-response vs Free-response Formats in Upper-division Conceptual Assessment

Poster – Bethany R. Wilcox, University of Colorado Boulder, 2510 Taft Dr. Unit 213, Boulder, CO 80302; Bethany.Wilcox@colorado.edu

Steven Pollock, University of Colorado Boulder

Free-response conceptual assessments, like the Colorado Upper-division

Electrostatics Diagnostic (CUE), provide rich, fine-grained information about students' reasoning. However, because of the difficulties inherent in scoring these assessments, the majority of the large-scale conceptual assessments in physics are multiple-choice. To increase the scalability and usability of the CUE, we set out to create a new version of the assessment that preserves the insights afforded by a free-response format while exploiting the logistical advantages of a multiple-choice assessment. We used our extensive database of responses to the free-response CUE to construct distractors for a new version where students can select multiple responses and receive partial credit based on the accuracy and consistency of their selections. Here, we offer examples of the questions and scoring of this new coupled multiple-response CUE. We also present a direct comparison of test statistics for both versions and potential insights into student reasoning from the new version.

PST2F06: 5:45-6:30 p.m. Flipped Upper-Division Physics at the Colorado School of Mines

Poster – Patrick B. Kohl, 1523 Illinois St., Golden, CO 80401; patkohlcsm@gmail.com

Eric S. Toberer, Colorado School of Mines

The flipped classroom is gaining popularity as a way of blending the best of online and in-person education, but efforts so far have been mostly (though not exclusively) focused on introductory classes. At CSM, we have developed and implemented two upper-division physics courses that use full or partial flips. Students are asked to watch one or more videos before class as preparation, with the actual class period occupied by Q&A, clicker questions, and various other activities. One of these two courses, PHGN 440, is a senior-level elective on solid state physics. The other, PHGN 462, is a core course on electrodynamics. In this poster we'll report on methods, motivations, and data, including but not limited to Youtube analytics, a qualitative survey, course evaluations, and a PER-based content inventory.

PST2F07: 5-5:45 p.m. Core Graduate Courses: A Missed Learning Opportunity?

Poster – Alexandru Maries, University of Pittsburgh, 5813 Bartlett, Pittsburgh, PA 15217; 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

Session FA: Remembering John Risley

Location: STSS 330
Sponsor: Committee on Educational Technologies
Date: Wednesday, July 30
Time: 8:30–10:30 a.m.

Presider: Danny Caballero

AAPT joins the North Carolina Section and the employees of WebAssign in this recognition of John Risley, who passed away at home after battling a rare and aggressive form of cancer. John served on the physics faculty at North Carolina State University from 1976 until his passing last year. His early career was in the field of atomic physics.

John had a tremendous impact on Physics Education and AAPT, particularly in areas of educational technology. In the late 1980s, John created Physics Academic Software, in collaboration with AIP, to publish peer-reviewed educational physics programs. In 1988, he and Joe Redish organized the Conference on Computers in Physics Instruction at North Carolina State University, which had a major impact on the field. During the 1990s, John developed summer workshops on educational technology for high school teachers and, later, oversaw the development of WebAssign, an online teaching and learning application used by millions of students worldwide.

John was a passionate teacher and physicist who cared deeply about how students learned and how teachers taught. Please join friends, colleagues, and admirers of John in this session dedicated to his memory.

FA01: 8:30-10:30 a.m. Bringing Textbooks to Life

Panel – Ruth Chabay, North Carolina State University, 515 E. Coronado Road Santa Fe, NM 87505; Ruth_Chabay@ncsu.edu

Bruce Sherwood, North Carolina State University

John Risley's vision of the future of physics education always included computers. At an early date he envisioned interactive online textbooks that seamlessly integrated exercises and problems with text. Now, as electronic textbooks evolve to include problem-solving activities, animations, video, and even computational modeling, we remember John's vision, reflect on how much textbooks have already changed, and speculate about the future.

FA02: 8:30-10:30 a.m. John Risley and 30 Years of Computers in Physics

Panel – Aaron Titus, High Point University, 833 Montlieu Ave., High Point, NC 27262; atitus@highpoint.edu

Peg Gjertsen, WebAssign

For 30 years, John Risley had an enormous impact on the use of computers in physics education. As editor of AIP's Physics Academic Software (PAS), John applied professional editorial resources and strategies to publish high-quality software that teachers could trust. Some of these applications, like Graphs and Tracks, EM Field, and Electric Field Hockey, are used to this day. John developed the Physics Courseware Evaluation Project (PCEP) to provide professional reviews of physics software and train high school teachers in the use of simulations and MBL software and hardware in the classroom. Finally, John oversaw the development of WebAssign and successfully launched this teacher-developed, publisher-independent online homework system so that it could be commercially viable, yet committed to a social mission. In this presentation, we will highlight computers in physics education during the last 30 years, connecting developments of the past to implementations of today.

Wednesday, July 30 Highlights

REGISTRATION 8 a.m.–3 p.m. Coffman Union ground floor

Session: Remembering John Risley, 8:30 a.m. STSS 330

MILLIKAN MEDAL: Eugenia Etkina
10:30–11:30 a.m. Northrop Auditorium

Post Deadline Posters 1–2:3 p.m. Coffman ground floor

Great Book Giveaway, 3–3:30 p.m. Coffman ground floor

Zooniverse in the Classroom, 3:30–5:30 p.m. STSS 131B

Mall of America Trip, 3:30–8:30 p.m. offsite

PERC Banquet and Poster Reception, 5–8:30 p.m.
Commons Hotel

FA03: 8:30-10:30 a.m. John Risley's Influence on Physlets and Open Source Physics

Panel – Wolfgang Christian, Davidson College, Davidson, NC 28035-6926; wochristian@davidson.edu

Mario Belloni, Davidson College

John Risley was a pioneer of computer-based learning. He actively promoted the use of computers in physics education at North Carolina State where he organized the first Conference on Computers in Physics Instruction in 1988 and founded both Physics Academic Software and WebAssign. His influence was especially strong in the North Carolina Section of the AAPT. In part due to John's influence, numerous computer-based learning projects were started in North Carolina. In this talk we will discuss his influence on two Davidson College curriculum development projects: Physlets and Open Source Physics. We discuss how our early experiments developing online curricular material have led to the second edition of Physlet Physics and Physlet Quantum Physics as stand-alone collections, joining Open Source Physics on ComPADRE to deliver almost 1,500 interactive exercises to teachers free of charge. Physlet Physics 2E: http://www.compadre.org/Physlets/ Open Source Physics: http://www.compadre.org/OSP.

Session FB: Seeking Employment in Academia

Location: STSS 412
Sponsor: Committee on Graduate Education in Physics
Co-Sponsor: Committee on Professional Concerns
Date: Wednesday, July 30
Time: 8:30–10:30 a.m.

Presider: Frances Mateycik

FB01: 8:30-9 a.m. The Liberal Arts College as a Professional Home

Invited – Juan Burciaga, Mount Holyoke College, Department of Physics, South Hadley, MA 01075-1424; jburciag@mtholyoke.edu

Many applicants applying to physics faculty openings at liberal arts colleges may be under the assumption that a liberal arts college is like a small university. Others make the assumption that research is a lesser priority among these institutions. Both of these common assumptions are fundamentally flawed. Even those who attended liberal arts colleges as students have only seen selected aspects of the life of a faculty member. How do we tread a fine balance while applying to these schools? How can we open the door to the job market of the liberal arts institutions? How do we distinguish the faculty application to a liberal arts college to one for a research university? Should we be applying to liberal arts colleges?

FB02: 9-9:30 a.m. Discipline Education Research: Need and Opposition

Invited – Genaro Zavala, Tecnologico de Monterrey, Garza Sada 2501, Monterrey, NL 64849 Mexico; genaro.zavala@itesm.mx

In this panel I will discuss some ideas that are connected to employment in academia. I will talk about the existence of a need for universities to improve student learning in different disciplines. There could be many reasons for this need such as having a lower dropout rate, improve assessments of programs by accreditation agencies, the reception of students with different needs in the digital age, or any other cause. Among the many actions an institution can take, universities have realized that one way to achieve better learning is to hire professors who are dedicated to research in education of the disciplines. This is very positive for our community since we have seen that there have been, perhaps not the number of calls for recruitment needed, but there have been indeed such calls. This gap between supply and demand can be caused by the considerable opposition to have discipline education research as an area of research of the discipline itself. Throughout the America (the continent!), I have noticed that the "establishment" in the departments of sciences is very difficult to change. Professors of many years oppose that discipline education research belong to their disciplinary departments. This issue is important and we have to take action to strengthen the field and help the barriers to discipline education research disappear. As a community we should take concrete and measurable actions to make this happen.

FB03: 9:30-10 a.m. Getting a Physics Position at a Two-Year College

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

There are numerous physics positions each year at two-year colleges around the nation. For these positions, there is a wide variety of candidate qualifications that these colleges list. In this presentation, I will discuss some of the qualifications that recent search committees valued, what you will probably have to do as a candidate being interviewed, and if selected, what you may experience as a new two-year college faculty member.

FB04: 10-10:30 a.m. Liberal Arts Department Hiring

Invited – Gordon Ramsey, Loyola University-Chicago, Chicago, IL 60626; gpr@anl.gov

Liberal Arts physics departments have a different focus than that of large research departments. As a result, the hiring process and subsequent responsibilities are unique. The balance between teaching and research lies somewhere between that of two-year colleges and large research universities. Teaching is the primary emphasis of these departments, but research is expected, although the expectations are less than that of research-dominated departments. Many require the inclusion of undergraduates in research. Therefore, the interview process includes discussion of teaching styles, research projects and how you would include undergraduates in these projects. You may be asked to teach a sample class to beginning majors and a separate presentation on research activities. The opportunity to work with undergraduates in and out of the classroom is gratifying. I will discuss what a typical liberal arts physics department looks for in a faculty member and how to prepare for this rewarding career.

Session FC: Reform Dissemination: Successful Examples II

Location: Tate Lab 170
Sponsor: AAPT
Date: Wednesday, July 30
Time: 8:30–9:50 a.m.

Presider: Vince Kuo

FC01: 8:30-9 a.m. Studio at CSM: Intro Physics and Beyond

Invited – Patrick B. Kohl, Colorado School of Mines, Golden, CO 80401; patkohlcsm@gmail.com

Studio and SCALE-UP (developed at RPI and NCSU respectively) have a long history in PER and at the Colorado School of Mines. CSM has been using Studio methods continuously since 1997, when the physics department implemented pilot sections of introductory calculus-based mechanics. Since then, Studio at CSM has expanded steadily. As of 2014, all of Physics I & II and Biology I are taught via Studio, along with pilot sections of Probability & Statistics. There are discussions in place to spread Studio to several other courses in the near term, including upper-division physics. In this talk, we'll briefly review the overall structure of Studio and some relevant performance data. The remainder will focus on the actual spread of Studio at CSM, highlighting a number of problems and how they were overcome, and reporting on the personal experiences of many of the instructors involved.

FC02: 9-9:10 a.m. LEAP: A Learner-centered Environment for Algebra-based Physics*

Contributed – Paula V. Engelhardt, Tennessee Technological University, *Cookeville, TN 38505-0001; engelhar@tntech.edu*

Steve Robinson, Tennessee Technological University

This presentation will focus on the curriculum development work that we have been doing with our algebra-based course sequence. LEAP* is guided by research on student learning of physics and builds on the work of the NSF supported project, Physics and Everyday Thinking (PET). Students work in groups to develop their understanding of various physics phenomena including forces, energy, electricity and magnetism, light and optics. Students utilize hands-on experiments and computer simulations to provide evidence to support their conceptual understanding. Traditional problem solving is scaffolded by using the S.E.N.S.E. problem solving strategy. An overview of the curriculum and assessment results will be presented.

*Supported in part by NSF grants (DUE-0737324 and DUE-1245684)

FC03: 9:10-9:20 a.m. Learning Assistants in Introductory Physics: Successes and Challenges at WVU

Contributed – Paul M. Miller, West Virginia University, Morgantown, WV 26506-6315; paul.miller@mail.wvu.edu

Jeffrey S. Carver, Kimberly Quedado, West Virginia University

In the fall of 2011, the West Virginia University Learning Assistants (LA) program began. Since the funding came as a component of a larger grant, our situation was well-suited to replication. Our program was designed after attending the LA Workshop at the University of Colorado. From the perspective of three years of LAs in our courses, we report successes, challenges, and lessons learned for both semesters of calculus-based introductory physics. We present content learning gains (from the FMCE and CSEM) and attitudes (from the CLASS) data. We show that the program has improved learning gains overall and in some targeted categories, such as first-generation students. Finally, we document and explore differences in course readiness between fall and spring enrollees that were revealed through program assessment. (This project is supported by the National Science Foundation under Grant No. EPS-1003907.)

FC04: 9:20-9:30 a.m. Research-based Reform: Faculty as Change Agents in Multiple Departments

Contributed – Adrienne L. Traxler, Florida International University, Department of Physics, Miami, FL 33199; altraxle@fiu.edu

Laird Kramer, Eric Brewe, David Brookes, Joseph Lichter ,Florida International University

The FIU Science Collaborative is a four-year project to reform undergraduate science education at Florida International University, driving institutional change through community building and faculty development across multiple departments. Each year, a cohort of faculty scholars undertakes transformation of their courses to incorporate and assess active learning. Scholars engage with reform in a variety of ways, from adoption of published research-based materials to creation of their own. We discuss examples and the bridges between faculty developers, faculty, and science education researchers that foster successful change.

FC05: 9:30-9:40 a.m. Implementation of a Flipped Classroom Across Multiple Sections

Contributed – Scott Paulson, James Madison University, Harrisonburg, VA 22807-0001; paulsosa@jmu.edu

We have implemented a flipped classroom for our calculus-based introductory physics sequence. The course was delivered by five instructors to approximately 250 students. Prior to "flipping," different sections were in various stages of reform, though all included some degree of interactive engagement. In our flipped courses we have much greater uniformity across sections in terms of content coverage. Student attitudes and outcomes will be discussed in light of data from end of semester evaluations and FCI pre/post tests.

FC06: 9:40-9:50 a.m. Seven Years of Change: Outcomes from the Science Education Initiative

Contributed – Stephanie Chasteen, University of Colorado Boulder, UCB 390, Boulder, CO 80309; stephanie.chasteen@colorado.edu

Katherine K. Perkins, University of Colorado Boulder

In 2005, the Science Education Initiative (SEI) at the University of Colorado was launched as a $5 million, university-funded project to support departments in improving science education (http://www.colorado.edu/sei). The SEI has funded work across seven STEM departments and dozens of courses to institute a scientific approach to educational reform driven by three questions: What should students learn? What are students learning? Which instructional approaches improve student learning? The SEI is structured with a small team of central staff, and a cohort of Science Teaching Fellows—postdocs, hired into individual departments, who partner with faculty to identify learning goals, develop instructional materials, and research student learning. Key elements of the program are its departmental focus and bottom-up structure. As the SEI draws to a close, we have an opportunity to reflect upon the impacts of the program. This talk will highlight the outcomes of the SEI model, including both affordances, and lessons learned.

Session FD: Introductory Courses

Location: Tate Lab 131
Sponsor: AAPT
Date: Wednesday, July 30
Time: 8:30–10 a.m.

Presider: Jim Madsen

FD01: 8:30-8:40 a.m. Should (and Can) We Teach Forces First?

Contributed – Andrew E. Pawl, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099; pawla@uwplatt.edu

Interactions are the heart of the mechanics course and forces are the fundamental representation of interactions. Thus, from an educational theory standpoint, teaching forces first in mechanics is an attractive option. Traditional instruction in mechanics, however, begins by teaching the concept of acceleration from a kinematic perspective before introducing Newton's second law. I briefly summarize a pedagogy that illustrates the potential utility of teaching forces before kinematics and presents evidence that college students in calculus-based mechanics perform equally well in courses that begin with forces as they do in courses that begin with kinematics.

FD02: 8:40-8:50 a.m. Phenomenon-based Learning Using Gadgets & Gizmos

Contributed – Matthew Bobrowsky, 11300 Classical Ln., Silver Spring, MD 20901; expert_education@rocketmail.com

Phenomenon-Based Learning (PBL) arose from a collaboration with teachers in Finland, which is now seen as a major international leader in education. PISA assessments showed that Finnish students were among the top in science proficiency levels. Of 74 countries, in 2009 Finland ranked #2 in science. (The U.S. ranked #23.) The PBL teaching philosophy combines elements of what's done in Finland with what's known about effective teaching based on science education research. The approach includes responsive teaching and inquiry-based collaborative learning, along with elements of problem-based learning, project-based learning, and hands-on experiments. The idea is to teach broader concepts and useful thinking and performance skills (as with NGSS) rather than asking students to simply memorize facts. By exploring first and getting to a theoretical understanding later, students are working like real scientists, having the opportunity to pursue creative approaches to understanding, learning more, and having fun in the process!

FD03: 8:50-9 a.m. Integrating Practices and Core Ideas into Introductory Physics Courses

Contributed – James T. Laverty, Michigan State University, East Lansing, MI 48824; laverty1@msu.edu

The current curriculum in most introductory college physics classes nationwide centers almost exclusively on content knowledge. Many recent national publications have called for an integration of scientific practices (e.g. Construct and Use Models) into the curriculum to teach students the process of science as well. In the Physics and Astronomy Department at Michigan State University, we are working with faculty to incorporate practices into the introductory physics courses. As part of this process, we are developing assessment items that integrate both the practices and core ideas of introductory physics. These items are being used as a stepping stone to develop curricular changes in the courses as well. This talk will focus on this development process and its current status.

FD04: 9-9:10 a.m. Project-based Learning to Foster Students' Learning in Introductory Physics

Contributed – N. Sanjay Rebello, Kansas State University, Department of Physics, Manhattan, KS 66506; srebello@phys.ksu.edu

Dong-Hai Nguyen, Ho Chi Minh City University of Pedagogy

Thanh-Nga Nguyen, Vietnam University of Transportation

Huong-Tra Do, Hanoi University of Education

Project-based learning (PBL) is a model of teaching in which students learn new knowledge and gain new skills by conducting learning projects that are closely related to their career or to real life. This model has proved to have positive effects in fostering students' self-motivation, activeness, and creativity in learning; as well as in helping students relate classroom knowledge to real life. At the University of Transportation (Vietnam) we conducted a study in which 200 first-year students majoring in transportation engineering took a course in calculus-based introductory physics in PBL format. Students worked in groups of three or four on several projects related to their major. We found that these students not only gained new physics knowledge and team-work skills but also became more capable of applying those knowledge and skills to real-life projects related to their major.

FD05: 9:10-9:20 a.m. Adapting Upside-down Pedagogies for a Hybrid Introductory Mechanics Studio

Contributed – Kristine E. Callan, Colorado School of Mines, Golden, CO 80401-1843; kcallan@mines.edu

Alex Flournoy, Vince Kuo, Colorado School of Mines

At Colorado School of Mines, the calculus-based introductory mechanics course has been taught using a hybrid lecture/studio model since 1997. As part of our continued efforts to refine the course, we have recently changed our pedagogy in an effort to further increase the level of interactive engagement and make the course more streamlined and coherent. In this current implementation, each topic is covered through a sequence of: 1) concise pre-lecture readings—written in-house; 2) a 50-minute lecture where concept questions and problem-solving examples are used to model application— i.e., no content delivery; 3) a 110-minute studio session where students collaborate in groups of three on experiments and scaffolded problem solving tasks; and 4) a series of example and homework problems—mostly written in-house. We will present data from two semesters of this pilot study, with ~1000 students taking the course during this time span.

FD06: 9:20-9:30 a.m. A Modern Physics Course Featuring Theory, Computation, and Experimentation*

Contributed – Marie Lopez del Puerto, University of St. Thomas, 2115 Summit Ave., OWS 153, St. Paul, MN 55105; mlpuerto@stthomas.edu

The transition from lower-level to upper-level physics courses is difficult for many students as the course material becomes more abstract and the mathematics more sophisticated. At the same time, students need computational skills such as plotting, fitting data, and modeling, as problems become more complex. We describe the development of a sophomore-level "Applications of Modern Physics" course that bridges the lower-level and upper-level curriculum for electrical engineering and physics students. The laboratory for the course is closely tied to the class and illustrates complex concepts such as quantized energy levels and probabilities in classical and quantum physics, following the theme of "particles in a box." Laboratories consist of tutorials using simulations, computational modeling using MATLAB, and brief, illustrative experiments. Thus, the course features the interplay between theory, computation, and experimentation that is central to the advancement of scientific knowledge.

*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.

FD07: 9:30-9:40 a.m. How "First Day" Activities in Physics Courses Generate Student Buy-In

Contributed – Jon D. H. Gaffney, Eastern Kentucky University, Richmond, KY 40475; jon.gaffney@eku.edu

Jacob T. Whitaker, Eastern Kentucky University

The first day of class sets the stage for the rest of the semester by setting expectations for the course. It is especially important to set those expectations in an active learning physics course because they are often quite different than expectations students have upon entering the course. Some faculty members have created activities specifically intended to generate such shifts, but whether those activities succeed in generating student buy-in may largely depend on how the activities are conducted. In this talk, we will present a hypothesis based on two existing theoretical constructs: instructor credibility and face threat mitigation. Together, those ideas describe one way that first day activities help generate a favorable classroom climate. We will discuss one activity that is used in the Physics for Teachers course at Eastern Kentucky University in terms of those constructs to demonstrate the plausibility of our hypothesis.

FD08: 9:40-9:50 a.m. C3PO: Customizable Computer Coaches for Physics Online

Contributed – K. Heller, University of Minnesota, School of Physics and Astronomy, Minneapolis, MN 55455; heller@physics.umn.edu

E. Frodermann, L. Hsu, Q. Ryan, University of Minnesota

B. Aryal, University of Minnesota-Rochester

Problem solving plays a crucial role in introductory physics. However, most introductory physics students are not skilled enough in problem solving to use it effectively as a learning tool. These students need coaching to improve their problem solving skills as they learn physics. Computers are a potential tool to provide this coaching since they are patient, non-threatening, and available 24/7 over the Internet. This talk will briefly describe such coaches and their success in the first semester of large calculus-based physics at the University of Minnesota. It will also describe the next generation of computer coaches that are designed to be easily modified by instructors. Important contributions to this presentation by: K. Crouse, E. Hoover, J. Yang (U. Minnesota), J. Docktor (U. Wisconsin, La Crosse), K. A. Jackson (U. Central Michigan) , and A. Mason (U.Central Arkansas). This work was partially supported by NSF DUE-0715615 & 1226197.

FD09: 9:50-10 a.m. Implementation of Web-based Problem Solving Computer Coaches in Classroom

Contributed – Bijaya Aryal, University of Minnesota-Rochester, 300 University Square, 111 S Broadway, Rochester, MN 55904; baryal@umn.edu

This presentation describes the integration of web-based computer coaches into small classes at University of Minnesota Rochester. Implementations have included students using the coaches outside of class as part of homework as well as the use of coaches as part of small group work inside the classroom. I will present the challenges faced by students and instructor both inside and outside the classroom, and describe the nature of students' group dynamics when they used the coaches to facilitate group work.
In addition, I will discuss the impact of the coaches on students' course performance and how in-class use of the coaches affected their subsequent usage outside class.

Session FE: Magnetism and Thermal Labs, Beyond First Year

Location: Tate Lab 133
Sponsor: Committee on Laboratories
Co-Sponsor: Committee on Apparatus
Date: Wednesday, July 30
Time: 8:30–10:20 a.m.

Presider: Gabe Spalding

FE01: 8:30-9 a.m. Magnetotransport Experiments in the Advanced Undergraduate Lab

Invited – E. Dan Dahlberg, University of Minnesota, School of Physics and Astronomy, Minneapolis, MN 55455-0213; dand@umn.edu

Resistivity and magnetotransport experiments performed on magnetic materials are ideal for teaching students aspects of both condensed matter physics and experimental techniques. An added benefit is room temperature resistivity and magnetotransport measurements on thin magnetic films are relatively easy to perform in an undergraduate laboratory. In this talk I will discuss the preparation of samples, the experimental equipment and techniques required for accumulation of the data and the data analysis. For the magnetoresistance data the focus will be on the anisotropic magnetoresistance which requires only modest magnetic fields, on the order of 0.01T. With larger fields the extraordinary Hall effect can be investigated (on the order of 0.7T required for Ni; larger fields required for Co and Fe). An added physics bonus is temperature-dependent measurements of the resistivity and the magnetotransport properties of the films.

FE02: 9-9:30 a.m. Improving the Quantification of Brownian Motion

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

Brownian motion experiments have become a staple in the undergraduate advanced laboratory as a means to measure the Boltzmann constant or to prove the atomic nature of matter. Yet, quantification of these experiments is difficult. Typical errors can easily be 10-15% and often students will produce measurements that are off by a couple orders of magnitude! In this talk I will discuss the individual sources of error in the experiment: sampling error, uncertainty in the diffusion coefficient, tracking error, vibration, and microscope drift. I will show you what sorts of error you should expect to get in your experiments and how you can get students to model that error computationally. Finally, I will describe some quick solutions that have allowed students in my lab to reduce their errors to less than 1%.

FE03: 9:30-10 a.m. Opportunities and Challenges Arising in Advanced Experimental Physics Courses

Invited – Jonathan McCoy, 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 this year, to explore the opportunities and challenges arising in advanced experimental physics courses more generally.

FE04: 10-10:10 a.m. 2-D and 3-D Random Walk Simulations of Stochastic Diffusion

Contributed – Bob Brazzle, Jefferson College, 2019 Brutus Ct., Fenton, MO 63026; bobbrazzle@yahoo.com

I will describe a physical Monte Carlo simulation using a number cube and a lattice of concentric rings of tiled hexagons. At the basic level, it gives students a concrete connection to the Statistical Mechanics concept of stochastic diffusion. I will also present a simple algorithm that can be used to set up a spreadsheet to track the evolving concentration of simulated "particles" (in contrast with the physical simulation, which tracks a single particle's motion). Although setting up the spreadsheet involves only elementary mathematics, it is robust enough to allow one to demonstrate or "discover" Fick's first Law, and a discretized version of the stochastic diffusion equation. Upper level undergraduates could thus use the spreadsheet to independently explore relevant advanced concepts (e.g. flux and concentration gradient). My AJP paper (November, 2013) describes this simulation as well as several extensions: lattices with different geometries in two and three dimensions.

FE05: 10:10-10:20 a.m. A Simple DTA Apparatus to Study Binary Phase Diagrams

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

Thermal analysis is a way to study a material's behavior during heating or cooling. Structural changes can be observed to occur either continuously, or at a given temperature, and with a specific signature. Differential Thermal Analysis, or DTA, is one of the most basic forms of thermal analysis. A DTA apparatus records the temperature difference of a sample and a reference material during heating and/or cooling. Deviation from a zero or near-zero baseline indicates specific events, such as melting, oxidation, dehydration, or decomposition, among others. In this talk a simple DTA apparatus will be discussed that can be used to explore the phase diagram of a simple binary alloy.

Session FF: PER: Modeling Student Engagement

Location: Tate Lab 166
Sponsor: AAPT
Date: Wednesday, July 30
Time: 8:30–10:10 a.m.

Presider: Andrew Boudreaux

FF01: 8:30-8:40 a.m. Facilitating Discourse in the High School Physics Classroom

Contributed – Scot A. Hovan, University of Minnesota, Minneapolis, MN 55417; scothovan@gmail.com

The Next Generation Science Standards (NGSS)[1] identify eight practices as essential to science and engineering, and several of these emphasize the role of students' constructing explanations, engaging in argumentation, and communicating scientific information. As a high school physics teacher using Modeling Instruction, this research will highlight one portion of a self-study analyzing experiences facilitating discourse in an attempt to move students closer to those practices espoused by the NGSS.

1. National Research Council (2012), *A Framework for k-12 science education: Practices, crosscutting concepts, and core ideas,* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education (Washington, DC: National Academy Press.)

FF02: 8:40-8:50 a.m. Analyzing Physics Students' Interaction Patterns in an ISLE Studio Class

Contributed – Binod Nainabasti, Florida International University, Miami, FL 33172; bnain001@fiu.edu

Kamal Kadel, Celestena Williams, David T. Brookes, Florida International University

Yuehai Yang, California State University, Chico

Students' interactions can be an influential component of an interactive learning environment. We analyze video data of students working together

Wednesday morning

while they learn physics from two consecutive semesters of a calculus-based introductory college physics course that implements the Investigative Science Learning Environment (ISLE) curriculum. We consider students' interaction patterns from two different viewpoints. The first is based on their positioning, in terms of equity, during peer interactions. The second is based on the structure of cognitive processes as described in the revised Bloom's Taxonomy. Using comparative analysis we examine the relationship between students' interactions in these two viewpoints and their learning as measured by performance in class exams and conceptual understanding. Additionally, we will attempt to identify the key characteristics and behaviors of "successful students," namely those who are able to fully exploit the affordances of a highly student-centered learning environment that places an emphasis on self-directed learning.

FF03: 8:50-9 a.m. Quantifying Patterns of Interaction in a Studio-based ISLE Physics Class

Contributed – David T. Brookes, Florida International University, Miami, FL 33199; dtbrookes@gmail.com

Binod Nainabasti, Florida International University

Yuehai Yang, California State University, Chico

We are interested to examine patterns of behavior and interactions amongst physics students as they learn in a highly interactive and student-centered learning environment. This environment is an introductory level studio-based ISLE physics class taught at Florida International University. We use a descriptive statistical approach and network analysis to identify productive or unproductive behavioral factors and try to quantify how these factors affect students' learning. We will report on interesting features and patterns that we discovered. In particular we consider the relative importance of factors such as how students participate in peer discussions while working on class activities, how much they take advantage of informal learning groups outside of class time, how they participate in whole-class discussions, and even whether students arrive on time to class or not.

FF04: 9-9:10 a.m. Describing Video Viewing Behavior in a Flipped Introductory Mechanics Course

Contributed – John M. Aiken, Georgia Institute of Technology, Atlanta, GA 30332; johnm.aiken@gmail.com

Shih-Yin Lin, Scott S. Douglas, Edwin F. Greco, Michael F. Schatz, Brian D. Thoms, Georgia Institute of Technology

Marcos D. Caballero, Michigan State University

In fall 2013, Georgia Tech began offering a "flipped" introductory calculus-based mechanics class as an alternative to the traditional large-enrollment lecture class. This class "flips" instruction by introducing new material outside of the classroom through pre-recorded, lecture videos that feature in-video "clicker" questions. Classroom time is spent working in small groups solving problems, practicing scientific communication, and peer evaluation. Video lectures constitute students' initial introduction to course material. We analyze how students engage with online lecture videos via "clickstream" data. Clickstream data consists of time-stamped interactions with the online video player. Plays, pauses, seeks, and other events are recorded when the student interacts with the video player. Patterns in this behavior can emerge and be used to highlight areas of interest in the video and improve the overall video delivery for future iterations of this course.

FF05: 9:10-9:20 a.m. Explanatory Coherence in an Introductory Physics for Life Scientists Course

Contributed – Benjamin D. Geller, University of Maryland, College Park, Department of Physics, College Park, MD 20742; geller@umd.edu

Benjamin W. Dreyfus, Julia S. Gouvea, Vashti Sawtelle, Chandra Turpen, University of Maryland, College Park

Life science students crave coherence among the science courses that they are required to take, and are frustrated when these courses fail to talk to each other in meaningful ways. In an effort to bridge disciplinary divides, we have iteratively designed and implemented an Introductory Physics for Life Scientists (IPLS) course that aims to unpack the physical mechanisms underlying a number of authentic biological phenomena. We draw on case-study data to examine what it looks like for students in our course to make connections between fundamental physical principles and meaningful biological questions. In particular, we explore the multiple ways in which an explanation can be "mechanistic" in the context of interdisciplinary sense making, and the affective markers that indicate satisfactory explanation. We argue that achieving explanatory coherence in an IPLS course demands that we take up authentic biological phenomena for which highly detailed accounts are not practical.

FF06: 9:20-9:30 a.m. Heuristics for Designing Interdisciplinary Learning Environments

Contributed – Chandra Anne Turpen, University of Maryland, College Park, Department of Physics, College Park, MD 20742;; chandra.turpen@colorado.edu

Vashti Sawtelle, Benjamin Dreyfus, Benjamin, Geller University of Maryland, College Park

Julia Svoboda Gouvea, University of Maryland, College Park & University of California, Davis

Our research team has been engaged in the iterative redesign of an introductory physics course for life science (IPLS) majors to explicitly bridge biology and physics in ways that are authentic to the disciplines. In our efforts to transform the IPLS course, we draw on the work of others who have argued that high-quality science instruction recognizes, leverages, and cultivates the productive beginnings of scientific inquiry in students' science reasoning by engaging students in making sense of phenomena, building and refining models, and generating satisfying explanations. It is unclear however what this learning process should look like at the college level as students also build from and refine more formal disciplinary knowledge that they have developed across their academic careers. Reflecting on our successes and failures in developing this course, we will present our best articulation of what educators should attend to in designing such interdisciplinary courses.

FF07: 9:30-9:40 a.m. Uncovering Long-term Trends in Students' Engagement with Online Homework

Contributed – Craig C. Wiegert, University of Georgia, Department of Physics and Astronomy, Athens, GA 30602-2451; wiegert@physast.uga.edu

Shahab Razavi, University of Georgia

A decade ago, web-based online homework was still somewhat of a novelty for many instructors; today it's a standard fixture in the introductory physics course. As online homework usage has grown, the ways in which students interact with this resource have changed. We present the analysis of seven years' worth of student usage data from one institution using the open-source LON-CAPA system. What implications do the evolving patterns of student activity have for instructors who want to maximize the pedagogical effectiveness of online homework?

FF08: 9:40-9:50 a.m. Physics Identity and Defining Interdisciplinary Affinity: Moving Beyond Performance

Contributed – Tyler Scott, Clemson University, Department of Engineering and Science Education, Clemson, SC 29634; tdscott@clemson.edu

Zahra Hazari, Geoff Potvin, Florida International University

Gerhard Sonnert, Philip Sadler, Harvard-Smithsonian Center for Astrophysics

While interdisciplinarity is often considered a worthy goal of education and a tool for better teaching, definitions of interdisciplinarity vary among education researchers and practitioners. In addition, researchers and practitioners usually focus on student performance on coursework that is considered to be interdisciplinary. What this perspective lacks is a consideration of the affective domain, namely student beliefs and attitudes about interdisciplinarity. Building on hypothesized dimensions of interdisciplinarity, we draw from a large-scale national survey to build a useful measure of interdisciplinary affinity. We also investigate how interdisciplinary affinity is related to students' physics and general STEM identities.

FF09: 9:50-10 a.m. Gender Differences in Introductory Physics Experience

Contributed – Jayson M. Nissen, 120 Bennet Hall, Orono, ME 04469; jayson.nissen@gmail.com

A gender-gap favoring males in outcomes such as conceptual knowledge, self-efficacy, attitudes and beliefs is common in introductory physics courses.[1] We investigated this issue by measuring students' in the moment stated feelings of self-efficacy and motivation throughout their daily lives, including in an introductory physics course. We also used trait surveys to measure gender gaps in the course consistent with prior research [1]. We found gender differences in physics favoring males on both measures. These findings trace the larger negative effect on female students' attitudes and beliefs about learning physics and their physics self-efficacy to their experiences occurring in the midst of physics instruction. This confronts researchers, educators, and administrators with the need for developing and implementing more equitable physics instruction.

1. L. Kost, S. Pollock, & N. Finkelstein, *PRST-PER*, **5**(1) (2009)..

FF10: 10-10:10 a.m. Beyond the Numbers: Finding Mechanisms to Support Diversity

Contributed – Vashti A. Sawtelle, University of Maryland, 1326 John S Toll Physics Bldg., College Park, MD 20742-2421; vashti.sawtelle@gmail.com

Julia Svoboda Gouvea, University of California, Davis

Chandra Turpen, University of Maryland, College Park

Understanding issues of diversity and equity in physics has historically taken the lens of documenting broad patterns of participation of women and ethnically underrepresented groups. This work has explored reasons for differing levels in participation including conceptual understanding, physics identity, and student self-efficacy. A common aim of this work has been to examine the impact of these variables on the prevalence of underrepresented groups in physics. We present an alternative lens on diversity and equity that centers on better understanding and supporting student trajectories of participation over time. Drawing from case study data of a biology major in an introductory physics class, we argue that access to a professional community of scientists must start from exposure to, participation in, and developing an affinity towards a variety of scientific practices. We articulate how this perspective informs a model of supporting diverse students who are commonly disenfranchised from physics.

Session FG: Broader Perspectives: Research-based Strategies to Improve the Teaching and Learning of Physics and Astronomy

Location: STSS 114
Sponsor: Committee on International Physics Education
Co-Sponsor: Committee on Space Science and Astronomy
Date: Wednesday, July 30
Time: 8:30–10:30 a.m.

Presider: Chandralekha Singh

FG01: 8:30-9 a.m. Conceptual Knots Exploration on Electromagnetic Phenomena and Quantum Mechanics

Invited – Marisa Michelini, PERU - DCFA - University of Udine, via delle Scienze 208 Udine, 33100 Italy; marisa.michelini@uniud.it

Lorenzo G Santi, Alberto Stefanel, Stefano Vercellati, Giacomo Zuccarini, PERU - DCFA - University of Udine

In the framework of Model of Educational Reconstruction our research is focused mainly on two aspects: conceptual knots exploration (CKE) and vertical paths design (VPD), focusing on the building of formal thinking. Empirical research is carries out for CKE by means of questionnaires, in/out tests, tutorials and Rogersian interviews. CKE is an essential element for VPD. It was carried out in the calibration process of a questionnaire for university students on quantum mechanics and in many steps of a Design Based Research aimed at VPD on electromagnetic phenomena. The first step of VPD research is reasoning analysis on magnetic interactions in Conceptual Labs of Operative Exploration in primary school activities and in informal learning environment. Educational reconstruction of conceptual nuclei in electromagnetic phenomena and CKE are taking into account to design electromagnetic IBL paths. It was experimented at different school level, monitoring students learning trajectories in teaching/learning intervention modules.

FG02: 9-9:30 a.m. Illuminating a Blind Spot in STEM Education Research

Invited – Edward Prather, University of Arizona, Center for Astronomy Education (CAE), Tucson, AZ 85721; eprather@as.arizona.edu

In this talk I will assert that much of STEM education research suffers because it fails to attend to the fundamental role played by a student's worldview. A person's worldview can be thought of as the set of (often implicit and often non-rational) beliefs, presuppositions, and assumptions about reality, which affect one's emotions, thoughts, and behaviors; influence one's symbolic creations; and determine what constitutes valid and important knowledge about the world. At its foundation, DBER naively assumes that if students better understand discipline knowledge and skills then they will be more likely to adopt scientific ways of understanding the world and develop positive beliefs about the role of science in society. I will discuss research being done at the University of Arizona on how to engage students in introductory physics and astronomy courses using curricula that gives scientific ideas empathy, scope and force, thereby helping learners develop scientifically compatible worldviews.

FG03: 9:30-10 a.m. From Instructional Goals to Grading Practices: The Case of Graduate TAs*

Invited – Edit Yerushalmi, Weizmann Institute of Science, 234 Herzl St. Rehovot, 7610001 Israel; edit.yerushalmi@weizmann.ac.il

Emily Marshman, Alexandru Maries, Chandralekha Singh, University of Pittsburgh

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. This work is supported by the National Science Foundation.

*This work is supported by the National Science Foundation.

FG04: 10-10:30 a.m. Enhancing Student Learning in a Flipped Classroom

Invited – Shih-Yin Lin, Georgia Institute of Technology, Atlanta, GA 30332-0002; hellosilpn@gmail.com

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

In this talk, we discuss our experiences "flipping" a large-enrollment introductory mechanics course and report student learning in this new class format. In our flipped class, pre-recorded lecture videos are used to introduce students to new materials outside of the classroom. Classroom time is spent on group discussion, problem solving, and practicing scientific communication. We place special emphasis in our flipped class on engaging students in scientific communication and reasoning from fundamental principles. We will discuss how students engage with different elements in the course (e.g. classroom meeting, online lecture, online homework, forum, at-home labs) and how such understanding of student behaviors can be used to improve student learning. We will also compare student learning in the flipped class to that in a traditional lecture class. We will also present some difficulties in a flipped classroom that we have encountered along the way.

Session FH: Mentoring in the Physics Community

Location: STSS 220
Sponsor: Committee on Physics in Undergraduate Education
Date: Wednesday, July 30
Time: 8:30–9:40 a.m.

Presider: Renee Michelle Goertzen

FH01: 8:30-9 a.m. Mentoring in the Ohio State University MS-to-PhD Physics Bridge Program (OSU-PBP)*

Invited – Jonathan Pelz, The Ohio State University, Physics, Columbus, OH 43210-1168; pelz.2@osu.edu

Jay Gupta, Michelle McCombs, Chris Porter, Andrew Heckler, Ohio State University

Effective and timely mentoring of Bridge students is extremely important to their ultimate success in transitioning to PhD programs, since many have substantial gaps in coursework, conceptual physics understanding, study and research skills, and/or "life skills" such as effective budgeting of time and personal finances. I will discuss the still-evolving mentoring efforts within the OSU-PBP, with particular emphasis on mentoring activities found to be effective, those that are not, and those that should have been implemented during our inaugural year. In addition to activities adapted from the Fisk-Vanderbilt and Michigan bridge programs, we are developing new academic mentoring activities in the form of physics tutorials and other materials for "Guided Group Work" sessions provided in conjunction with advanced undergraduate physics courses that OSU-BP students are taking. These sessions are greatly valued by the students, and have proven to be effective in improving conceptual understanding, critical thinking, and problem solving skills.

*The OSU-PBP was formed with substantial financial and other support from the American Physical Society and from Ohio State University.

FH02: 9-9:30 a.m. Learning to be a More Effective Research/Project Mentor

Invited – Eric J. Hooper, University of Wisconsin-Madison, 5507B Sterling Hall, Madison, WI 53706-1582; ehooper@astro.wisc.edu*

Christine Pfund, Janet Branchaw, Robert Mathieu, University of Wisconsin-Madison

The University of Wisconsin-Madison has developed, field tested, and publicly released research mentor training materials for several STEM (science, technology, engineering and mathematics) disciplines, including physics and astronomy, to help improve the educational experience and ultimate success of research trainees at several career stages, from high school students to post-doctoral scholars. While initially aimed at the mentoring of undergraduate researchers at research extensive institutions, the topics are broad enough (e.g., expectations, communication, understanding, diversity, ethics, independence) to be applicable to mentoring in a wide range of project-based educational activities. Indeed, these materials have been modified, only modestly, to prepare graduate students and undergraduates to mentor high school students. This talk will describe the research mentor training seminar and illustrate how the training can be adapted and implemented.

*Sponsored by: Renee Michelle Goertzen

FH03: 9:30-9:40 a.m. Developing Resilient Physics Students Through Regular Reflection and Empathetic Feedback

Contributed – Dimitri R. Dounas-Frazer, California Polytechnic State University, San Luis Obispo, San Luis Obispo, CA 93407; ddounasf@calpoly.edu

Low retention in the sciences is due in part to students' rejection of faculty and graduate students as role models and their perception of faculty as unapproachable. Improving retention of science students therefore requires the creation of educational spaces where students feel better connected to instructors. To this end, we are piloting a system that facilitates regular student reflection and personalized instructor feedback to foster supportive relationships between students and instructors. Students choose one of four topics to guide their reflections. Instructor responses acknowledge and empathize with students' difficulties, recognize their efforts to improve, and provide them with additional resources whenever appropriate. Thus, instructors and students engage in a mentoring-style relationship to support students in overcoming challenges to their development as learners. In this talk, we report preliminary results on how regular reflection and feedback shape students' experiences in a physics course and how students' reflections evolve over time.

Session FI: Teacher Communities: Supporting Beginning Teachers of Physics

Location: STSS 220
Sponsor: Committee on Teacher Preparation
Date: Wednesday, July 30
Time: 9:50–10:30 a.m.

Presider: Colleen Megowan-Romanowicz

FI01: 9:50-10:20 a.m. STEMteachersNYC – Starting an Effective Physics Teacher Support Organization

Invited – Fernand Brunschwig, Columbia University, Teachers College, New York, New York 10027; fbrunsch@gmail.com

STEMteachersNYC, affiliated with the American Modeling Teachers Association, has achieved strong growth since its founding by a group of physics teachers in May 2011, with a membership of 240 in February 2014. The group has organized a total of 32 highly workshops between founding and February, 2014, including four 3-week Summer Modeling Instruction Workshops and 28 three-hour weekend workshops. See STEMteachersNYC.org for details. I will describe the explicit organizing strategies and the process we used to generate this dynamic growth. STEMteachersNYC has successfully leveraged experienced teachers' expertise as workshop leaders and has been supported financially almost entirely through fees paid by the teachers attending the workshops. I will explore in detail the scalability of what we have done, as well as the potential for widespread implementation to support teachers, especially beginners, by enhancing their pedagogic content knowledge and teaching skills.

FI02: 10:20-10:30 a.m. Making Collaboration Worth Your Time

Contributed – Kate E. Miller, Washington-Lee High School, Arlington Public Schools, VA, 119 5th St. SE, Washington, DC 20003; katemiller1027@gmail.com

"Collaboration": a buzzword frequently used but infrequently made meaningful. I am a first-year teacher and member of a team of four teachers in three districts (two states) that has successfully collaborated for three years. This group has been invaluable in improving my instructional design and implementation throughout my critical first year. Together, we align content on a near daily basis, use backwards planning, and create common formative/summative assessments. Our success stems from our group norms—(1) a commitment to instructional alignment, (2) decisions made through consensus rather than majority, (3) a critical but respectful approach towards new ideas and (4) a reflective stance of our group processes. I will share tools, protocols, and technology that have allowed us to be effective and efficient in our collaboration. This team is supported by the Knowles Science Teaching Foundation which strives to support new science teachers in becoming expert teachers.

Session FJ: Strategies for Teachers and Professors to Support Female Students

Location: STSS 312
Sponsor: Committee on Women in Physics
Date: Wednesday, July 30
Time: 8:30–9:20 a.m.

Presider: Jessica Bartley

FJ01: 8:30-9 a.m. Gateway to STEM: Improving 3-D Spatial Skills

Invited – Sheryl Sorby, The Ohio State University, 19817 Haapapuro Rd Houghton, MI 49931; sheryl@mtu.edu

The ability to visualize in three dimensions is a cognitive skill that has been shown to be important for success in engineering and other technological fields. For engineeRring, the ability to mentally rotate 3-D objects is especially important. Unfortunately, of all the cognitive skills, 3-D rotation abilities exhibit robust gender differences, favoring males. The assessment of 3-D spatial skills and associated gender differences has been a topic of educational research for nearly a century; however, a great deal of the previous work has been aimed at merely identifying differences. For nearly two decades, the author has been conducting research aimed at identifying practical methods for improving 3-D spatial skills, especially for women engineering students. This presentation details the significant findings obtained over the past several years through this research and identifies strategies that appear to be effective in developing 3-D spatial skills and in contributing to student success. Data obtained for students enrolled in introductory physics courses will also be presented.

FJ02: 9-9:10 a.m. Spatial Reasoning/Visual Cognition Skills – Does it Matter?

Contributed – Ximena C. Cid, University of Washington, Seattle, WA 98195-0001; xcid@uw.edu

It is known that science students have higher spatial reasoning skills than non-science students, and previous research suggests that physicists have the highest spatial reasoning skills amongst STEM fields. Though a lot of research in engineering education has shown a correlation between success of female students and their spatial reasoning scores, little work has been done in physics. This talk will discuss some work that has been done exploring the relationship between spatial reasoning skills and student success in physics.

Session FK: Additional Strategies to Support Female Students

Location: STSS 312
Sponsor: AAPT
Date: Wednesday, July 30
Time: 9:20–10:10 a.m.

Presider: Jessica Bartley

FK01: 9:20-9:30 a.m. Effect of Instructor Gender on Modeling Instruction FCI Scores

Contributed – Daryl McPadden, Florida International University, Miami, FL 33199; dmcpadden621@gmail.com

Eric Brewe, Florida International University

This study focuses on the impact of instructor gender on the gender gap in students' scores on the Force Concept Inventory (FCI) in Modeling Instruction (MI) courses at Florida International University (FIU). A previous study from Brewe et. al. has shown that while MI had increased FCI scores as compared to traditional lecture courses, the gap between male students' scores and female students' scores increased over the semester.[1] Data was taken from 599 students at FIU, over 19 semesters, with 11 different instructors (4 female, 7 male). Effect size is calculated from the difference in female students' scores from male students' scores, and the effect size is compared between instructor genders. A linear regression is also used to determine if instructor gender is a significant factor in predicting a student's FCI score post-instruction.

1. E. Brewe et. al., *Phys. Rev. ST-PER* **6**, 010106 (2010).

FK02: 9:30-9:40 a.m. Studio Seating Arrangements and the Gender Gap in Introductory Physics

Contributed – Andrew G. Duffy, Boston University, Physics, Boston, MA 02215; aduffy@bu.edu

Bennett B. Goldberg, Pankaj Mehta, Boston University, Physics

Fall 2013 was our first large-scale studio implementation in the introductory physics course for life-science majors at Boston University. That semester, we observed a gender gap in both the three studio sections of the course and the two lecture sections that was similar to that observed at other places. Specifically, males, on average, did better than females. In spring 2013, we experimented with different seating arrangements in the three studio sections. One section had random groups, another had homogeneous groups, and the third had heterogeneous groups. We will report on the outcome of that experiment.

FK03: 9:40-9:50 a.m. Discussing Underrepresentation as a Means to Increasing Female Physics Identity

Contributed – Robynne M. Lock, Texas A&M University Commerce, Department of Physics and Astronomy, Commerce, TX 75429-3011; robynne.lock@tamuc.edu

Reganne Tompkins, Clemson University

Zahra Hazari Florida, International University

Despite the fact that approximately half of high school physics students are female, only 21 percent of physics bachelor's degrees are awarded to women. In a previous study, drawn from a national survey of college students in introductory English courses, five factors commonly proposed to positively impact female students' choice of a physical science career were tested using multivariate matching methods. The only factor found to have a positive effect was the explicit discussion of the underrepresentation of women in physics. In order to explore this further, a case study of the classes of one teacher reported to discuss the underrepresentation of women was conducted. Two classroom underrepresentation discussions were recorded, students and teacher were interviewed, and relevant student work was collected. Analyzing the case study data using a figured worlds framework, we report on how discussing underrepresentation may create opportunities to increase the physics identities of female students.

FK04: 9:50-10 a.m. Examination of Pathways to Excellence Scholarship Program for Women in STEM Fields

Contributed – Joseph Di Rienzi, 4701 North Charles St., Baltimore, MD 21210-2404; jdirienzi@ndm.edu

Notre Dame of Maryland University (NDMU) is in the third year of an NSF S-STEM grant (1060595), Pathways to Excellence, providing 10 scholarships annually to academically talented women undergraduates with demonstrated financial need who are pursuing degrees in mathematics, physics, computer information systems, or engineering. The program has a tri-part mentoring system with a faculty member in the student's discipline, a peer from the program and an alumnae. Scholars also take an annual thematic seminar course. Each student constructs a career development plan in assistance with her faculty mentor and sets measurable annual goals. In addition, all scholarship students are requested to have an experiential experience. As a result, NDMU aims to strengthen its role in increasing the numbers of well-educated and skilled women employees from diverse backgrounds, including first-generation college students, in technical and scientific areas. Early assessment of the program produced modifications and now these can be evaluated.

FK05: 10-10:10 a.m. Women's Ways of Becoming Physicists: Identity and Trajectory

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

Michael E. Loverude, California State University Fullerton

Physics is the least representative of the hard sciences, with only 21% of bachelor's degrees in the United States during 2008-2010 awarded to females and 13% to non-white U.S. citizens (AIP, 2011). Our preliminary work suggests that many students from underrepresented groups have little experience with the cultural norms and expectations of disciplinary communities and can face significant challenges in integrating. These challenges are often sensitive and not obvious to faculty and mentors. We present case studies constructed from interviews with two female students who have recently completed their BS in physics. We describe their experiences in terms of advancing along a trajectory towards becoming physicists. Our results suggest that supporting students through their major touches not only upon academic and professional expectations, but also social interactions within and beyond the school setting.

Ceremonial Session: 2014 AAPT Robert A. Millikan Medal Presented to Eugenia Etkina

Location: Northrop Auditorium
Date: Wednesday, July 30
Time: 10:30–11:30 a.m.

Presider: Gay Stewart

Students of Physics: Listeners, observers, or collaborative participants?

Eugenia Etkina

Eugenia Etkina, Rutgers University, 10 Seminary Place, New Brunswick, NJ 08901

Scientists and especially physicists have their own, unique ways of developing new knowledge, solving new problems, and communicating about what they do. These form a set of cultural norms and practices that we call "physics." Can students become enculturated into physics in a one-year introductory course, or does "doing physics" remain the exclusive purview of professionals who have acquired their skills through years of training? Development of the Next Generation Science Standards, revisions to AP courses, and a new MCAT suggest that these aspects of physics (and other sciences) are as valuable as the final product of scientific labor—concepts and mathematical representations—that traditionally have been the sole focus of science courses. Science practices are the central elements of all these innovations. In my talk I will describe curricular approaches that make these practices a centerpiece of learning physics without losing conceptual and mathematical focus. Ways to assess these complex practices will also be discussed.

Session TOP07: PERTG Town Hall

Location: Tate Lab 166
Sponsor: AAPT PERTG
Date: Wednesday, July 30
Time: 11:30 a.m.–12:30 p.m.

Presider: MacKenzie Stetzer

This is a meeting for members of the Physics Education Research Topical Group.

Session TOP08: Web Resources for Teaching Astronomy

Location: STSS 114
Sponsor: Committee on Space Science and Astronomy
Date: Wednesday, July 30
Time: 11:30 a.m.–1 p.m.

Presider: Kevin Lee

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

Session TOP09: Physics on the Road: Developing a Manual

Location: STSS 230
Sponsor: Committee on Science Education for the Public
Co-Sponsor: Committee on Professional Concerns
Date: Wednesday, July 30
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 TOP11: The 5th International Conference on Women in Physics

Location: STSS 330
Sponsor: Committee on Women in Physics
Co-Sponsor: Committee on International Physics Education
Date: Wednesday, July 30
Time: 11:30 a.m.–12:30 p.m.

Presider: TBA

The 5th International Conference on Women in Physics will be held in Canada in August 2014. Come hear about plans for the conference.

Session GA: PER: Examining Content Understanding and Reasoning

Location: STSS 220
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1–3 p.m.

Presider: Hunter Close

GA01: 1-1:10 p.m. Vector Addition in Different Contexts: A Fine-Grained Study

Contributed – Philip B. Southey, University of Cape Town, 10 Zion Road, Claremont, Cape Town, WC 7700 South Africa; philsouthey@gmail.com

Saalih Allie, University of Cape Town

The acquisition metaphor of learning is often used by teachers of physics: Students acquire a particular concept, and then transfer this concept to new contexts. In particular, one might say students acquire the mathematical concept of "vector addition" and apply it in (transfer it to) numerous physical contexts. In this study, 200 freshmen taking an introductory physics course were asked to calculate the total force, total displacement and total momentum in simple contexts involving vector addition at right angles. Another similar group of 200 students were asked to calculate the net force, net displacement, and net momentum. The students did significantly worse when adding momenta, and they did significantly better when asked to calculate the "net" quantity (rather than the "total" quantity). These results are inconsistent with a basic "acquisition -transfer" perspective of learning. A fine-grained analysis of subsequent interviews and questionnaires was also conducted.

GA02: 1:10-1:20 p.m. Adding and Subtracting Vectors: The Problem with the Arrow Representation

Contributed – Andrew F. Heckler, The Ohio State University, Columbus, OH 43210; heckler.6@osu.edu

Thomas M. Scaife, University of Wisconsin - Platteville

While a number of studies have investigated student understanding of vector addition and subtraction as relevant to introductory physics, virtually all of these studies have only considered the arrow representation of vectors. In this study, we demonstrate that significantly -- and often overwhelmingly -- more students can correctly add and subtract vectors in the textual, component ijk-format compared to the arrow format in both generic and physics contexts. Furthermore, by prompting students for physical explanations of results, we find that students also exhibit an equal if not better understanding in the ijk-format compared to the arrow format. The arrow format typically induces an intuitive application of arrows, often resulting in incorrect answers. Overall, we find that the ijk-format tends to prompt students to use the arrow format correctly (and not vice versa), and this suggests that teaching the arrow format alone may not be as productive as teaching both representations simultaneously.

GA03: 1:20-1:30 p.m. Training Factors Affecting Improvement in Student Fluency with Vector Algebra

Contributed – Brendon D. Mikula, The Ohio State University, Columbus, OH 43210-1168; bdmikula@gmail.com

Andrew F. Heckler,The Ohio State University

In addition to struggling with deep comprehension of physics concepts, students also struggle with essential, procedural skills that are necessary for the types of problem solving expected of them during introductory physics classes. Students in both semesters of introductory physics (mechanics and E&M) and in multiple populations (algebra and calculus-based) have been shown to struggle with the essential skills of computing vector components and vector products. In this presentation, we present data on the effectiveness of a number of training conditions on student fluency with these vector skills. Through the use of simple computer-based training with answer-based feedback, the effects of different types of feedback—as well as the presentation order of sub-skills and concepts—are investigated.

GA04: 1:30-1:40 p.m. Evaluating Mathematics Skills and Impact in a First-Semester Mechanics Course

Contributed – William R. Evans, University of Illinois at Urbana-Champaign, 303 Paddock Dr. W, Apt A1, Savoy, IL 61874; wevans2@illinois.edu

A collection of targeted math skills questions were developed and incorporated into the standard, weekly homework exercises in a first semester, calculus-based mechanics course for science and engineering majors at the University of Illinois. These questions were designed to test the math skills that would nominally be used during the homework that week. This presentation gives our analysis of the students' performance on the math skills questions as compared with the corresponding physics questions. We conclude by discussing some of the implications of this study in regards to transfer of learning and possible contributing factors toward student difficulties in mechanics, as well as possibilities for improving student performance in calculation-based exercises.

GA05: 1:40-1:50 p.m. Student Strategies Solving Graphically Based Physics Problems Invoking the Fundamental Theorem of Calculus

Contributed – Rabindra R. Bajracharya, University of Maine, Orono, ME 04469; ab_study@yahoo.com

John R. Thompson, University of Maine

We have been investigating student understanding and application of the Fundamental Theorem of Calculus (FTC) in different physics contexts involving definite integrals. We conducted 14 semi-structured individual interviews with introductory physics students. Our analysis, using grounded theory, elicited various strategies to solve graphically based FTC problems. While many students struggled initially, at some point during the interviews students displayed the relevant and requisite mathematical knowledge, suggesting that they failed to access and/or apply the knowledge in the given physics contexts. Similar to prior studies on students dealing with mathematically based physics problems, we found the analysis perspectives of epistemological framing and epistemic games productive in interpreting some of the choices of strategies, the strategies themselves, and some individual steps observed. The framing perspective helps explain students' strategy-switching based on representations available or context familiarity. We discuss our findings and relate our results to those in the literature.

GA06: 1:50-2 p.m. Do Individual Thinking Strategies Consistently Inform Reasoning Approaches?*

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

MacKenzie R. Stetzer, University of Maine

This study was motivated by research findings suggesting that student conceptual and reasoning competence demonstrated on one task often fails to be exhibited on another. Even after targeted instruction, many undergraduate physics students fail to build reasoning chains from fundamental principles even though they possess the required knowledge and skills to do so. Instead, they often rely on a variety of intuitive reasoning strategies. In this study, we examined the extent to which students employ intuitive reasoning across multiple contexts (both related and unrelated). In addition, we wanted to see if the tendency to use a particular class of reasoning approaches (e.g., intuitive or formal) may be attributed to individual student thinking strategies in general. Data from introductory calculus-based physics courses will be presented and implications for instruction will be discussed.

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

GA07: 2-2:10 p.m. Metacognition and Epistemic Games in IPLS Problem Solving

Contributed – Charles Bertram, University of Central Arkansas, Lewis Science Center, Conway, AR 72035-0001; ajmason@uca.edu

Andrew Mason, University of Central Arkansas

A metacognitive exercise in problem solving was given to an introductory physics for life sciences (IPLS) class over the course of the fall 2013 and spring 2014 semester. The exercise featured scaffolding in the form of a rubric students could use to note where they struggled in a group problem solving effort. One of the concerns was that students who are not physics majors do not necessarily have the same epistemic framework as physics majors would for the classroom. As such, we examine written artifacts from the students' reflection activities for evidence of different epistemic games. We also describe a comparison of written artifacts to pre-post data from the FCI, MPEX, and CLASS surveys.

GA08: 2:10-2:20 p.m. Exploring the Role of Metacognition in Qualitative Reasoning*

Contributed – Thanh K. Le, University of Maine, Orono, ME 04473-4462; thanhle@maine.edu

MacKenzie R. Stetzer, University of Maine

Mila Kryjevskaia, North Dakota State University

Metacognition, the monitoring and regulation of one's thinking, plays an important role in developing conceptual understanding and facilitating effective problem solving. To date, relatively little work has focused on the role of student metacognition in qualitative inferential reasoning. We have collected audio, video, and real-time written data in order to identify instances of socially mediated metacognition[1] that occur while introductory physics students work through qualitative problems. In particular, we use multi-part questions that tend to elicit inconsistencies in student reasoning, even when students possess the requisite conceptual understanding. This work is part of a broader effort to identify methods for improving students learning in physics by explicitly supporting and enhancing students' metacognitive abilities. Preliminary findings as well as specific examples will be presented.

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

1. M. Goos, P. Galbraith, & P. Renshaw, "Socially mediated metacognition: Creating collaborative zones of proximal development in small group problem solving," *Educational Studies in Math.* **49**(2), 193-223 (2002).

GA09: 2:20-2:30 p.m. Investigating the Metacognitive Calibration of Students in Introductory Courses

Contributed – Beth A. Lindsey, Penn State Greater Allegheny, Mc Keesport, PA 15131-7644; bal23@psu.edu

Megan L. Nagel, Penn State Greater Allegheny

"Calibration" is an aspect of metacognition that describes how well students assess their own knowledge. We have been engaged in a multi-year project to investigate the metacognitive calibration of students enrolled in introductory physics and chemistry courses at a small campus of a large public university. When assessed at the end of the semester, we found a large disparity between students' confidence in their ability to answer questions compared to their actual ability to provide the correct answer on a large number of questions that spanned the course material. We further investigated student calibration in a series of interviews designed to examine which question features and student behaviors might lead students to assess their knowledge more accurately. Data from written questions and one-on-one student interviews will be presented, and the implications these have for future investigations into student metacognition will be discussed.

GA10: 2:30-2:40 p.m. Identifying Blended Ontologies for Energy

Contributed – Benjamin W. Dreyfus, University of Maryland, Department of Physics, College Park, MD 20742; dreyfus@umd.edu

Ayush Gupta, Edward F. Redish, University of Maryland, College Park

Energy is an abstract concept, but students and experts alike reason about energy using ontological metaphors: metaphors that indicate what kind of a thing energy is. These metaphors include energy as a substance ("This object has a lot of energy") and energy as a vertical location ("It dropped down to a lower energy"). Both of these metaphors can be productive, but each one has its limitations. In our previous work, we have shown that students and experts can productively combine the substance and location metaphors for energy and coordinate them coherently. Here, we examine instances in which students are using both metaphors, and argue that, in some cases, students blend these two separate metaphors into a single ontology for energy. To determine this, we employ an integrated methodology, analyzing both the verbal metaphors and the gestures that the students use.

GA11: 2:40-2:50 p.m. Exploring Blended Ontologies via Gestures

Contributed – Ayush Gupta, University of Maryland, College Park, Room 1320 Physics Building, College Park, MD 20742; ayush@umd.edu

Benjamin W. Dreyfus, Edward F. Redish, University of Maryland, College Park

In recent years there has been increased interest in understanding the ontological metaphors in play in experts' and novices' reasoning about energy. By ontological metaphors we mean metaphors that indicate what kind of a thing energy is. These metaphors include energy as a substance ("This object has a lot of energy") and energy as a vertical location ("It dropped down to a lower energy"). We are investigating how experts and novices might (or might not) coordinate and/or blend these two metaphors when reasoning about energy. In this talk, we will focus on how to use gestures to understand such ontological blending.

GA12: 2:50-3 p.m. Educational Data Mining: Results from in Vivo Experiments to Teach Different Physics Topics

Contributed – Daniel Sanchez-Guzman, Cicata - Legaria, Instituto Politécnico Nacional Legaria, Del. Miguel Hidalgo, Mexico City, Mexico; dsanchezgzm@gmail.com

Alejandro Ballesteros-Roman, Cicata - Legaria, Instituto Politécnico Nacional

Educational Data Mining (EDM) uses different algorithms for analyze response and behavior in the teaching-learning process, these algorithms let researches to analyze and classify students' behavior or state of knowledge from different concepts; most of these algorithms have not been tested in Physics Education Research, this work presents the results obtained from applying three algorithms used by EDM for teaching different physics concepts applied to in-vivo experiments. These algorithms are: decision tree, rule induction, and fuzzy rule induction. The in-vivo experiments correspond to different active learning methodologies derived from research master degree thesis in the Physics Education Research Department from the Applied Science and Advance Technology Research Center of the National Polytechnic Institute in Mexico.

Session GB: A Potpourri of Physics and Physics Teaching Ideas

Location: STSS 330
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1–2:30 p.m.

Presider: Melissa Vigil

GB01: 1-1:10 p.m. Using PhET Simulations to Enhance Science Inquiry with Elementary Students

Contributed – David R. Henry, SUNY Buffalo State, 358 Crosby Ave., Buffalo, NY 14217; henryd@buffalostate.edu

Chris Shively, SUNY Buffalo State

The authors of National Science Education Standards and the Next Generation of Science Standards (NGSS) have called for students to engage with experiences that promote scientific inquiry. The documents emphasize the use of technology to help students collect, organize, analyze, interpret, present and debate data in ways similar to scientists, but technology can be expensive. To achieve this goal with little funding, teachers can use the Physics Education Technology (PhET) simulations, designed at the University of Colorado, in conjunction with inexpensive hands-on materials to do powerful science inquiry. The simulations permit students to see invisible phenomena and enable them to build conceptual models of phenomena such as buoyancy, energy, conductivity, and gravity. Students can use the simulations to apply the science and engineering practices called for in the NGSS. We will present inquiry activities appropriate for elementary students in two areas, Buoyancy and Electricity.

GB02: 1:10-1:20 p.m. Exploration of Talent-Specific Teaching Strategy in Elementary Science Lessons

Contributed – Youngseok Jhun, Seoul National University of Education, Seocho Gu Seocho dong 1650, Seoul, 137-742 Korea; youngseok.jhun@gmail.com

Hana Jung, Seoul National University of Education

Science classes are usually conducted by written and spoken language with a logical and mathematical approach, but there are some students who lag behind in developing verbal linguistic and logical mathematical intelligence especially low grade classrooms. It can be difficult for them to keep up with the classes. As students experience continuous failure in science, they will become chronically lethargic and have low self esteem. It will also increase the chances of breakdowns, creating a vicious cycle -- students' little concentration from their failure can turn into more serious failure. In this study, we are to find solutions for this situation using teaching and learning strategies to help all students achieve their goals and feel interest in science lessons even if they are not good at verbal or mathematical skills. To achieve our goal, we observed the students' activities in low grade classes to find out how the students are different in intelligent development. We derived the strategy to stimulate each student's various talents and use them in learning science. We'd like to share our findings in the procedure of the research.

GB03: 1:20-1:30 p.m. The Propagation of Peer Instruction: A Case Study*

Contributed – Raina M. Khatri, Western Michigan University, Kalamazoo, MI 49008; raina.m.khatri@gmail.com

Charles Henderson, Western Michigan University

Not many instructional strategies created by the STEM Education research community become widely used. However, Peer Instruction, a classroom strategy that engages students during lecture, has been successful in reaching many teachers and classrooms. In this study, we used interviews with the original Peer Instruction team, publications, press releases, grant information, and other sources to construct a picture of the propagation strategies that led to Peer Instruction's widespread adoption. The results of this study could help future educational developers make an informed propagation plan to increase the impact of their work.

*Supported by NSF Grant No. 1122446

GB04: 1:30-1:40 p.m. Surveying Students' Understanding of Measurement Uncertainty and Proportional Reasoning: Update

Contributed – Jeffrey D. Marx, McDaniel College, Westminster, MD 21158-4100; jmarx@mcdaniel.edu

Karen Cummings, Southern Connecticut State University

In this talk we will present an update of our efforts to develop a survey instrument to probe undergraduate, non-science majors' understanding of measurement uncertainty and proportional reasoning ability. Using everyday items (scales, luggage, and kittens) and activities (weighing oneself and traveling) we have attempted to create an interview instrument and protocol that evokes and accommodates a wide range of responses and interpretations. Although still in the development phase, we can report that our population has a very difficult time applying measurement uncertainty and proportional reasoning, even after instruction designed to improve this population's understanding of these physical principles.

GB05: 1:40-1:50 p.m. If You Build It, They Will Come

Contributed – James M. Dugan, Hastings College, Hastings, NE 68901; jdugan@hastings.edu

Physics departments, at all institutions, of all sizes, are continuously trying to increase their number of majors. Hastings College, a small private school located in south central Nebraska, with a full-time student enrollment of one thousand is no different. In 1995 the physics department had 15 majors. In the fall of 2013 that number was 38. What precipitated this 250% growth? In this talk I will describe how by implementing and expanding a number of program changes and recruitment strategies, focused on a year-long senior project experience, these striking enrollment increases were achieved.

GB06: 1:50-2 p.m. Lesson Study as a Vehicle to Improve College Physics Teaching

Contributed – Sachiko Tosa, Niigata University/Wright State University, Faculty of Education, Ikarashi-2-cho, 8050-banchi, Nishi-ku Niigata-shi, Niigata 950-2181 JAPAN; stosa@ed.niigata-u.ac.jp

When it comes to teaching, university faculty members in science fields are often isolated and many of them are wondering alone how they can help students overcome difficulties in understanding the concepts they present, especially in large lecture classes. This study examines how a collaborative lesson planning and discussion scheme called Lesson Study can help both students and faculty in introductory physics and other science classes at two colleges. Faculty's attitudes towards collaboration and active learning strategies were measured by pre/post-program survey (N=14). The preliminary results indicate that the process helped faculty members feel more comfortable asking their colleagues questions about their teaching. The results also indicate that Lesson Study helped 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 program sustainable.

GB07: 2-2:20 p.m. Radiation Equilibrium in Bohr's Atom, and the Nucleus Radius

Contributed – Vic Dannon, Gauge Institute, Minneapolis, MN 55414-1192; vic0@comcast.net

Bohr proposed that the electron orbits have angular momentums that are discrete multiples of h-bar. Consequently, the orbits are occupied by standing waves, and no radiation takes place in them. However, radiation by an accelerating charge is a fact of electrodynamics. And Bohr's argument defies experiment, and places the electron-proton atom out of the laws of Electrodynamics. We will assume that the Proton's orbits too, have angular momentums that are discrete multiples of h-bar. And that the energy radiated by the accelerating proton into the electron field equals the energy radiated by the accelerating electron into the proton field. Keeping the orbits energies in a dynamic equilibrium. This allows us to compute the Nucleus Radius of the Electron-Proton Atom. We obtain a radius of the order of $1/10^{12}$.

GB08: 2:20-2:30 p.m. Fostering Positive Cultural Changes in College STEM Departments*

Contributed – Joel C. Corbo, CU Boulder, Physics Department, Boulder, CO 80309-0390; joel.corbo@colorado.edu

Noah Finkelstein, Melissa Dancy, Stanley Deetz, Paul Chinowsky, Colorado University, Boulder

In recent years, many efforts have been made to enact changes in STEM departments, courses, and curricula in order to improve the experiences of undergraduate students. These efforts have generally focused on disseminating curricula and pedagogy, developing reflective teachers, or enacting institutional policy, but they have rarely succeeded in creating large-scale, systemic cultural changes in departments. Our project tackles the problem of STEM education improvement via an "all of the above" approach by working with individual faculty, whole departments, and university policymakers simultaneously. Moreover, our departmental cultural change efforts will be one of the first attempts at such a holistic reform, and as such could serve as a model for similar efforts in other departments and at other institutions. We will report on our initial findings into the challenges and possibilities inherent in such an approach.

*Project supported by the Association of American Universities.

Session GC: Best Practices in Educational Technology II

Location: STSS 412
Sponsor: Committee on Educational Technologies
Date: Wednesday, July 30
Time: 1–3 p.m.

Presider: Frances Mateycik

GC01: 1-1:10 p.m. How I Met Your Motherboard: Integrating Smartphones into Classrooms

Contributed – Colleen L. Countryman, North Carolina State University, Raleigh, NC 27695; cblanz@ncsu.edu*

Michael A. Paesler, William R. Sams, North Carolina State University

In the current technological environment, most students own smartphones. These smartphones contain internal sensors capable of collecting data in instructional physics labs. By utilizing these devices, university teaching laboratories can decrease their dependence on costly proprietary software, sensors, and sensor interfaces. Also, since students are typically already familiar with personal devices, pedagogical hurdles often encountered in instructional physics labs are diminished. MyTech is a series of labs that takes advantage of these devices in a first-semester mechanics lab at NC State. The MyTech labs require no more than a smartphone (and a computer webcam) and free software to collect data. We present preliminary results from the shifts in kinematic graph skills, attitudes and technological anxiety that occur with the MyTech lab curriculum to those that occur with a traditional lab curriculum. We discuss some common obstacles encountered in this case study and how best to avoid them.

*Sponsored by Dr. Robert Beichner and Dr. Michael Paesler

GC02: 1:10-1:20 p.m. Results from eTALK: Effects of Real-Time Distance Labs

Contributed – William Sams, North Carolina State University, Raleigh, NC 27695-8202; wrsams@ncsu.edu

Colleen Lanz, M A. Paesler, North Carolina State University

eTALK is a reform of introductory physics laboratories that involves students using their own laptops and simple equipment rather than proprietary probes and loggers. Students participate in a portable lab experience that removes the need for a dedicated laboratory space while maintaining synchronous contact with teaching assistants and other students. Students use Blackboard Collaborate, Gmail, and WebAssign to communicate with the instructor and submit results and conclusions, while simultaneously harnessing the capabilities their own electronic devices to make high-quality measurements without complicated and unfamiliar equipment. Evaluation of the eTALK initiative has been under way for several semesters in calculus-based introductory mechanics at NC State with data collection ranging from conceptual assessments and attitude surveys to video monitoring for analysis of student activities, interactions, and behaviors. Effects on student performance, understanding, confidence, autonomy, lab skills, and attitudes are all being examined. Selected results from the study will be presented and discussed.

GC03: 1:20-1:30 p.m. Flexible Physics Mobile: YouTube Bridges from Lecture to Lab

Contributed – Duncan L. Carlsmith, University of Wisconsin-Madison, 1150 University Ave., Madison, WI 53706; duncan@hep.wisc.edu

Aditya Singh, Lauren Wielgus, University of Wisconsin-Madison

Flexible Physics Mobile develops video-based educational objects bridging lecture and laboratory for undergraduate high-enrollment courses in introductory physics at the University of Wisconsin-Madison. Each video provides a brief pedagogical introduction to the physical concepts to be explored and a visual introduction to the actual equipment to be encountered, both tailored in sophistication to student preparation. The 2011-12 Educational Innovation project Flexible Physics for the Google World explored techniques and protocols (video, stills, screencasts, animations, clickable transcripts, editing techniques). It developed educational objects for UW-Madison Physics 104 and 208 which were deployed with Flash technology through a department server. The 2013014 Flexible Physics Mobile project has redeployed legacy educational objects on YouTube (search for Flexible Physics UW Madison) and has produced a suite of new videos for Physics 103, Physics 207, Physics 201, Physics 202, and Physics 109. The videos are a) discoverable, b) maintainable, c) closed captioned, d) available on mobile devices, and e) tagged and linked to related material. Usage analytics data indicates high student engagement and retention. The challenges, successes, and results of this project will be described.

GC04: 1:30-1:40 p.m. Newton's Third Law: A Sample Online Interactive Video Vignette

Contributed – Priscilla W. Laws, Dickinson College, Carlisle, PA 17013; lawsp@dickinson.edu

David P. Jackson, Maxine C. Willis, Dickinson College

Robert B. Teese, Rochester Institute of Technology

Kathy Koenig, University of Cincinnati

The LivePhoto Physics Group has been creating and testing a series of Interactive Video Vignettes (IVVs) involving introductory physics topics. Vignettes are designed for web delivery as short, ungraded exercises to supplement textbook reading, or serve as pre-lecture or pre-laboratory activities. Each Vignette includes videos of a physical phenomenon, invites the student to make predictions, complete observations and/or analyses, and, finally, compare findings to the initial prediction(s). A sample Vignette on Newton's third law will be shown, and the speaker will discuss why the group believes the Vignette is effective. (NSF #1122828 & #1123118).

GC05: 1:40-1:50 p.m. Impact of IVV on Student Understanding of Newton's Third Law*

Contributed – Kathleen M. Koenig, University of Cincinnati, 2600 Clifton Ave., Cincinnati, OH 45221; kathy.koenig@uc.edu

Robert Teese, Rochester Institute of Technology

Priscilla Laws, David Jackson, Maxine Willis, Dickinson College

One of the short interactive video vignettes (IVVs) developed by the LivePhoto Physics Group targets student understanding of Newton's third law. This seven-minute interactive web-delivered vignette was designed to supplement textbook readings. It includes real-world and laboratory-based video segments and users must answer multiple-choice questions. Throughout the IVV, 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 Newton's third law, a controlled study was conducted involving three professors who each taught two sections of an introductory physics course, with only one section of students completing the IVV as a homework assignment. Students in all sections 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 Newton's third law.

*Work supported by NSF DUE #1123118 & 1122828

GC06: 1:50-2 p.m. Software for Interactive Video Vignettes*

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

Thomas J. Reichlmayr, Rochester Institute of Technology

Priscilla W. Laws, David Jackson, Dickinson College

Software developed in the LivePhoto Physics Interactive Video Vignettes Project is being used in introductory physics courses, introductory biology courses and advanced physics lab courses. Interactive Video Vignettes are short, online activities that combine narrative videos with interactive, hands-on elements for the user such as video analysis or multiple-choice branching questions, in which the user's answer affects the sequence of elements that follow. The software that powers vignettes is delivered over the Internet and runs in a normal browser on the user's device. The same software can be used to make Interactive Web Lectures for flipped classrooms, online learning, and MOOCs. A Java application that teachers can use to create their own vignettes and online lectures is under development and is available for testing. The software will be demonstrated and the status of the development will be described.

*Supported by NSF grants DUE-1122828, DUE-1123118 and DUE-12110685.

GC07: 2-2:10 p.m. Next Generation PhET Simulations: New Features for Teaching and Learning*

Contributed – Katherine K. Perkins, University of Colorado Boulder, UCB 390, Boulder, CO 80309-0001; Katherine.Perkins@colorado.edu

Stephanie V. Chasteen, University of Colorado Boulder

With the emergence of new educational platforms (e.g. iPads and Chromebooks) and opportunities for increased interoperability among educational technologies, the PhET Interactive Simulations project at University of Colorado Boulder recently launched a new initiative to create next-generation PhET simulations. These next-generation simulations are built in HTML5 with new touch-and-tablet compatible designs (See video: http://bit.ly/1kpZ5TG; and sims http://phet.colorado.edu/en/simulations/category/html). This work brings a unique opportunity to build-in new functionality—functionality that would be common across all of the simulations and that would enable new teaching, learning, assessment, and research opportunities. We have solicited input and ideas from the broader education community. In this session, we summarize the list of new features under consideration—such as, recording user interactions with the simulations, combining tabs from multiple simulations, pre-setting simulation configurations, or enabling screen capture with annotation— and discuss how these features will extend teaching and learning opportunities, including addressing the NGSS.

*This work is funded in part by the Gordon and Betty Moore Foundation, and the William and Flora Hewlett Foundation.

GC08: 2:10-2:20 p.m. Using PhETs in Astronomy

Contributed – Rhoda Berenson, New York University, New York, NY 10010-3140; rb143@nyu.edu

The University of Colorado website, phet.colorado.edu, provides simulations of physical situations designed to help students grasp scientific concepts. This talk will present activities that use these simulations to elucidate some topics in astronomy. In particular, it will describe using PhETs to study: "Orbits, Gravity and Kepler's Law," "What Stars are Made of," "Stellar Temperature" and "Stellar Luminosity."

GC09: 2:20-2:30 p.m. Intelligent Coaches for Problem Solving in Physics*

Contributed – Leonardo Hsu, University of Minnesota, Minneapolis, MN 55455; lhsu@umn.edu

Kristin Crouse, Evan Frodermann, Ken Heller, Qing Ryan, University of Minnesota

Intelligent tutoring systems (ITSs) were introduced more than 40 years ago and the idea of Computer Assisted Instruction (CAI) has been in existence almost since the birth of computers. The University of Minnesota Physics Education Research Group has combined that work with research from cognitive science and physics education to develop an instructor-modifiable web-based system for providing students with coaching in solving physics problems. This system, called Customizable Computer Coaches for Physics Online (C3PO), is designed to help students develop expert-like problem-solving skills by providing them with individualized guidance and feedback while they practice solving problems. In this talk, we describe the system, its place in the constellation of ITSs for physics education in the universe of CAI, and the plans for future development.

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

GC10: 2:30-2:40 p.m. The Software Framework for Customizable Computer Coaches for Physics Online*

Contributed – Kristin N. Crouse, University of Minnesota, Minneapolis, MN 55455-0213; crou0048@umn.edu

Evan Frodermann, Ken Heller, Leon Hsu, Bijaya Aryal, University of Minnesota

The University of Minnesota Physics Education Research Group has been developing Customizable Computer Coaches for Physics Online (C3PO), a web-based system designed to help students develop expert-like problem solving skills. C3PO delivers instructor-modifiable coaching programs that provide students with individualized guidance and feedback while solving physics problems. In this talk, we discuss the software architecture of the system and the design process and demonstrate some of the system's capabilities.

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

GC11: 2:40-2:50 p.m. Computer Programming Made Easier with Canopy

Contributed – Larry Engelhardt, Francis Marion University, Florence, SC 29501-0547; lengelhardt@fmarion.edu

Computational physics is hard. Students need to learn computational thinking, at the same time that they learn the syntax of a programming language, as well as specific algorithms, without letting any of this get in the way of the physics! In this talk, we will demonstrate "Canopy" which is an environment for the Python programming language that helps makes this process a little bit easier. In particular, Canopy includes a new debugger (released spring 2014) that makes it easier than ever to understand the mechanics of a computer program.

GC12: 2:50-3 p.m. CUDA: At-Home Supercomputing

Contributed – Jacob Knoles, California State University Chico, Chico, CA 95926; jknoles1@mail.csuchico.edu*

Eric Ayars, California State University Chico

NVIDIA CUDA is a simple programming API that harnesses the computing power of the Graphical Processing Unit, or GPU, and puts it directly into everyday users' hands. The significance of this concept is that modern GPUs can have upwards of 3000 processing cores, as opposed to a typical quad-core processor. These extra cores allow users to complete complex and time-consuming calculations in fractions of a second. Parallel programming is leading the way in modern High Performance Computing

(HPC) and CUDA presents massively parallel performance as a budget friendly, and extremely effective, option. We will demonstrate how to use CUDA, along with Python, to improve computational speed by three orders of magnitude or more using a "stock" laptop.

Sponsored by: Eric Ayars

Session GD: Bridging Engineering, Math, and Physics

Location: Tate Lab 170
Sponsor: Committee on Physics in Two-Year Colleges
Date: Wednesday, July 30
Time: 1–2:10 p.m.

Presider: Renee Lathrop

GD01: 1-1:10 p.m. Lessons Learned from an Integrated Calculus and Physics Learning Community

Contributed – Dwain M. Desbien, Estrella Mountain Community College, Avondale, AZ 85392; dwain.desbien@emcmail.maricopa.edu

Rebecca Baranowski, Holly Dison, Estrella Mountain Community College

For the last three years, EMCC has been offering and integrated Calculus I and University Physics class. This talk will share results comparing traditional classes to the integrated courses on the FCI and exams. Discussion of the reordering of topics to better match will also be discussed along with future directions and goals.

GD02: 1:10-1:20 p.m. Fatal Friction Flaw

Contributed – Alan J. Scott, University of Wisconsin-Stout, 800 Broadway St., S. Menomonie, WI 54751; scotta@uwstout.edu

On the evening of Aug. 13, 2011, a temporary structure used to provide cover and support concert entertainment equipment at the Indiana State Fair collapsed when hit with straight-line winds from an approaching storm. Seven people died and 58 were injured. The methodology and results of the forensic physics analysis (or engineering analysis) will be presented in addition to a case-study, simplified model of the incident appropriate for an introductory physics classroom. The engineering company Thornton Tomasetti, Inc., out of Chicago was hired for the investigation which is the same company that investigated the I35W bridge collapse in Minneapolis back in 2007.

GD03: 1:20-1:30 p.m. Patterns Approach (Introduction): Engaging Students in Scientific and Engineering Practices

Contributed – Heather Jean Moore, Fairfax County Public Schools, Arlington, VA 22206; heatherjeanmoore@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 are continually engaged in scientific practices, starting with anchoring experiments that contextualize four common mathematical patterns in physics: linear, quadratic, inverse, and inverse square. Inquiry and engineering experiences serve to spiral these anchoring patterns with new physics concepts, developing conceptual, graphical, and symbolic understanding. Students are asked to compare low- to high-evidence predictions, collaboratively build models based on data, assess the quality/limitations of their models, develop proportional reasoning skills, and harness the power of computational reasoning. Bridging math, science and engineering in this way builds a coherent, experiential case for the process of science and student interest in STEM careers. The Patterns Approach has been used within freshman through IB courses and is published in *The Science Teacher* March, 2013.

GD04: 1:30-1:40 p.m. Patterns Approach: Classroom Whiteboard Discussions

Contributed – Scott J. Murphy, St. Joseph's Preparatory Academy, Philadelphia, PA 19146; scott.justin.murphy@gmail.com

Within the confines of The Patterns Approach to Physics, it is important to facilitate the idea of science as a cooperative endeavor. Scientists continually use research conducted by others, critically review the work of others, and work in teams to solve problems. In the classroom, this can take the form of a whole class discussion, during which students present their findings from experimental data. Groups can analyze the effect of different variables to prevent repetitive presentations and allow for meaningful sharing of information. Students will gain valuable insights into determining the credibility of a source, creating a persuasive presentation by displaying information aesthetically, and communicating their results in an efficient manner. As students become more proficient in these discussions, they will come to understand a key component of the science and engineering communities.

GD05: 1:40-1:50 p.m. Patterns Approach: Building Scientific Reasoning by Breaking Models

Contributed – Jordan Pasqualin, Rowe-Clark Math & Science Academy, Chicago, IL 60625; jpasqualin@gmail.com

Within the confines of The Patterns Approach to Physics one important topic is Model Failure. There is much pedagogical value in having students attempt to apply a predictive model or pattern to experimental data and fail. As students use The Patterns Approach to build scientific reasoning skills, they gain expertise in detecting and explaining patterns in nature. There is plentiful opportunity for students to experience the very real limitations of using scientific models to make predictions about systems. Models are useful inasmuch as they are able to make accurate predictions, but students often cling to familiar models, even when inappropriate. When models fail it creates opportunity to evaluate assumptions embedded in a scientific investigation and ask new questions, two key skills that are critical to genuine scientific pursuit. When students are taught to break models they are better able to deal with failure, refine understandings, and extend the inquiry process.

GD06: 1:50-2 p.m. Patterns Approach: Integrating STEM Within Engineering Projects

Contributed – Bradford K. Hill, Southridge High School, 9625 SW 125th Ave. Beaverton, OR 97008; bradford_hill@beaverton.k12.or.us

Within the confines of the Patterns Approach to Physics, one means of bridging engineering, math, and science practices is to embed inquiry investigations (the science) within engineering design tasks. Students seek patterns within the data to build mathematical models (the math) used for optimizing engineering design decisions. Four such engineering projects are presented: Wind Turbine, Bridge Design, Barbie Bungee Adventure, and Dynamic Paintings. In all of these examples students must both engage in the engineering cycle to address the problem and the inquiry cycle to generate data to inform their design. These projects, while familiar to many physics classrooms, are presented in the context of the Pattern Approach to teaching physics so the supporting materials and examples discussed would allow a teacher to easily use them.

GD07: 2-2:10 p.m. Using Engineering Design to Engage Middle School Students in Physics

Contributed – M. Colleen Megowan- Romanowicz, Arizona State University, Tempe AZ 85282; Megowan@asu.edu

The Next Generation Science Standards (NGSS) call for science teachers to design instruction and engage their students in eight specific Science and Engineering Practices. Many of these practices are familiar to middle school teachers and are already embedded in their teaching practice, but a few--specifically "defining problems" and "designing solutions"--are novel ideas to them. Many teachers express concern that they have no formal education in engineering design nor do they have the experience, time, and resources necessary in their classrooms to create meaningful engineering activities for their students. In this session I will describe a project that is specifically designed to increase teachers' confidence and competence in implementing the eight NGSS science and engineering practices in their middle school classrooms. I will describe some of the PD in which teachers engaged and how teachers ultimately enacted engineering projects in their classrooms.

Session GE: PER: Evaluating Instructional Strategies II

Location: Tate Lab 131
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1–2:50 p.m.

Presider: Eleanor Sayre

GE01: 1-1:10 p.m. Interplay Between Beliefs and Learning in Mixed-level Introductory Physics

Contributed – Brent W. Barker, Roosevelt University, Chicago, IL 60605; bbarker@roosevelt.edu

Kayla Fouch, Roosevelt University

Introductory calculus and non-calculus physics classes are combined into a single section with an additional calculus discussion section afterwards. Others have found a correlation between student beliefs about learning physics and conceptual learning. We investigate this correlation within our mostly life-sciences population and explore the effect of the calculus discussion section on these beliefs and learning.

GE02: 1:10-1:20 p.m. Conceptual Gains with Embodied Learning in Resistive Circuits

Contributed – Alex M. Barr, Howard Community College, College Park, MD 20740; abarr@howardcc.edu

Mark Baumann, Randi Ludwig, University of Texas at Austin

We report on conceptual learning gains associated with an embodied learning activity for resistive circuits. The activity, Circuit Theater, involves students playing the role of electric charges as they act out the behavior of various circuits involving batteries and light bulbs. A subset of questions from the Determining and Interpreting Resistive Electric Circuits Concepts Test (DIRECT) were administered before and after Circuit Theater activities in a calculus-based physics course at Howard Community College. Normalized gains for students participating in Circuit Theater average 49% after one week of activities. We also report on possible learning retention suggested by performance on the unit exam and the final exam.

GE03: 1:20-1:30 p.m. Teaching Quantum Mechanics through Project-based Learning

Contributed – Gintaras K. Duda, Creighton University, 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, however, has focused on introductory courses. This talk will explore 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 was 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 talk will describe how PBL pedagogy was implement in an upper-division physics course and will explore student learning in light of the new pedagogy and embedded metacognitive self-monitoring exercises, and the effect of the PBL curriculum on student attitudes, motivation, and epistemologies.

GE04: 1:30-1:40 p.m. Quantum Interactive Learning Tutorial (QuILT) on Mach Zehnder Interferometer with Single Photons*

Contributed – Chandralekha Singh, University of Pittsburgh, Pittsburgh, PA 15260; clsingh@pitt.edu

Emily Marshman, University of Pittsburgh

We are developing and assessing a quantum interactive learning tutorial (QuILT) on Mach Zehnder Interferometry with single photons to expose students to contemporary applications of quantum mechanics. The QuILT strives to help students develop the ability to apply quantum principles in physical situations, explore differences between classical and quantum ideas, and organize knowledge hierarchically. The QuILT also helps students learn about delayed choice experiments, first proposed by John Wheeler. It adapts visualization tools to help students build physical intuition about non-intuitive quantum phenomena and focuses on helping them integrate qualitative and quantitative understanding and discriminate between concepts that are often confused. Details of the development and assessment will be discussed. We thank the National Science Foundation for support.

*We thank the National Science Foundation for support.

GE05: 1:40-1:50 p.m. Developing Metacognitive Skills in Conjunction with Conceptual Understanding of Physics*

Contributed – Nathaniel C. Grosz, North Dakota State University, Department of Physics, Fargo, ND 58108-6050; Nathaniel.C.Grosz@my.ndsu.edu

Mila Kryjevskaia, MacKenzie R. Stetzer, University of Maine

Effective learners possess a diverse repertoire of metacognitive skills that they consciously deploy to support and guide their thinking. Adopting new thinking approaches is complex and demanding for novice learners, but the process can be facilitated by instructors actively supporting the development of students' metacognitive skills. As part of an ongoing investigation of student reasoning approaches in physics courses, we wish to identify instructional strategies that are effective at promoting the development of metacognitive skills in conjunction with the development of conceptual understanding of physics. We have been probing the effectiveness of such strategies across multiple learning environments (e.g., interactive lectures, laboratory). We will present data from question sequences purposefully designed to evoke metacognitive behavior. Results from individual and group work will be presented and compared. Implications for instruction will be discussed.

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

GE06: 1:50-2 p.m. Classroom Observation Coding to Study Success Factors in Studio Physics

Contributed – Larry Medsker, George Washington University, 725 21st St. NW, Washington, DC 20052; lrm@gwu.edu

Gerald Feldman, Noel Klingler, Zoe Pierce, George Washington University

Improvements in student learning through interactive-engagement methods have been inconsistent over a range of institutions. Possible factors for these variations include institutional differences and instructor effectiveness. As part of a project to explore the key elements of successful algebra-based studio courses, we are conducting systematic observations and analyses of various classroom environments with regard to teaching methods, cognitive engagement, and instructor-student interactions. Our data are recorded as a chronological series of codes in the Teaching Dimensions Observational Protocol (TDOP) which reflect the classroom activities taking place at particular times. In order to test the efficacy of the TDOP computer-based tool, we are using an evidence-based approach for choosing an efficient set of codes grounded in PER. We will discuss the coding design process and our insights into studio-mode courses. We will outline the important factors impacting active learning in the classroom and discuss how the observations inform the broader study of successful studio physics.

GE07: 2-2:10 p.m. Identifying the Different Implementations of Studio Physics: Document Analysis

Contributed – Ozden Sengul, Georgia State University, Atlanta, GA 30303; osengul1@student.gsu.edu

Joshua Von Korff, Georgia State University

Physics education research (PER) indicates that research-based instructional strategies (RBIS) such as studio classes and research-based text materials (Physics by Inquiry) could be used widely to improve students' learning gains and conceptual understanding. However, the effectiveness of RBIS is not universal; non-physics majors fail to understand subjects in algebra-based courses at some institutions. This could be due to many reasons, such as different implementations of studio physics or different teaching strategies. Course documents also have impacts on the learning environment. As part of a collaborative study among GSU, GW and UCF, we have collected and analyzed available course documents, such as experiments and quizzes. The analysis is based on the differences between course documents (experiments, activities) among these three institutions and comparison of these documents to those prepared by the instructors with PER-based documents.

GE08: 210-2:20 p.m. Student Characteristics Influencing Success in Studio Physics: First Steps

Contributed – Jacquelyn J. Chini, University of Central Florida, Orlando, FL 32816; jacquelyn.chini@ucf.edu

Jarrad W.T. Pond, University of Central Florida

Studio physics courses and other interactive engagement methods have been found to improve student learning gains at multiple institutions. However, the same level of success is not found in all secondary implementations of these methods. There are several possible explanations for these differences in success, such as institutional differences and instructor effectiveness. As part of a project to explore the essential components for success of algebra-based studio physics courses, we would like to describe and compare characteristics of student populations at institutions with different levels of success. Studio-mode courses may be particularly vulnerable to differences in student populations since their student-centered nature places more responsibility on students. We will present the results of interviews conducted with faculty, student assistants and enrolled students at three universities to explore the characteristics they felt most significantly impacted individual students' success in studio mode courses and how these results inform the larger study.

GE09: 2:20-2:30 p.m. Implementing PER-based Tutorials in the Second Semester Algebra-based Lecture-supported Mini-studio

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

Archana Dubey, Jacquelyn J. Chini, Talat S. Rahman, University of Central Florida

Following the positive impact of the lecture-supported mini-studio format on student understanding in our first-semester algebra-based courses, we present the results of implementing the mini-studio format in our second-semester algebra-based courses. The mini-studio format provides improved integration of traditional lecture, recitation, and laboratory components for a large number of introductory students who cannot be served by our limited number of full-studio courses. During the three-hour laboratory portion of the mini-studio, students complete student-centered worksheets containing PER-based materials (e.g., exercises from Maryland Open Source Tutorials, Minnesota Context-Rich Problems, etc.) and then take quizzes on paper. Some students worked in our previous laboratory format, which entailed an instructor-led problem-solving session followed by individual quizzes completed online. We will investigate the effects of the mini-studio format on student understanding of second-semester material and on student attitudes toward physics and compare these results to those of other formats used for our second-semester algebra-based courses.

GE10: 2:30-2:40 p.m. Implementing Computational Modeling in a High Needs High School Classroom

Contributed – Samuel Martin, Dekalb County School System, 2953 Westbury Dr., Decatur, GA 30033; scorcerrer@yahoo.com*

Shih-Yin Lin, John M. Aiken, Scott S. Douglas, Michael F. Schatz, Georgia Institute of Technology

We describe our current efforts to implement computational modeling and video analysis in the introductory mechanics curriculum at Clarkston High School, a Metro Atlanta public school. In collaboration with Georgia Tech,we have tested and implemented teacher-designed course materials. Clarkston serves a largely low-income refugee community. This causes unique challenges. Improving computer literacy is a large focus, and is necessary in preparation for the next-generation science standards. The classroom activities replace traditional lab activities with computer analysis using student-filmed videos, Tracker (free motion tracking software), and special scripts using the free programming language VPython. We discuss student performance and student engagement during lessons.

*Sponsored by Michael Schatz

GE11: 2:40-2:50 p.m. Physics I MOOC – Student Performance Analysis

Contributed – David H. Lieberman, CUNY/Queensborough Community College, Bayside, NY 11364-1497; dlieberman@qcc.cuny.edu

We have analyzed the performance of students enrolled in University of Colorado Physics I MOOC. The performance of the MOOC students is compared with that of students in the "Brick and Mortar" version of the course, Physics 1110. Identical instruments (FMCE, exams, homework) were used to evaluate both groups. While the completion rate of students enrolled in the MOOC was much lower than for those in the "Brick and Mortar" class, MOOC students performed as well as and had learning gains as great as those in the "Brick and Mortar" class. When MOOC students are compared with a similar group of Physics 1110 students, based on FMCE pre-tests, their performance lags but still compares favorably with that of students in a typical Physics I class.

Session GF: Introductory Courses II

Location: STSS 312
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1–2:40 p.m.

Presider: Matt Evans

GF01: 1-1:10 p.m. How Do We Motivate Students to Study the Text?

Contributed – Brad R. Trees, Ohio Wesleyan University, Department of Physics and Astronomy, Delaware, OH 43015-2398; brtrees@owu.edu

As physics instructors, we often bemoan the tendency for students to read the text only as a means to an end—namely, solving assigned end-of-chapter problems. How can we motivate students to study the text before jumping headfirst into homework problems? This talk discusses an effort to provide a framework within which students interact with dynamic content in a digital-only format. The framework is based upon a series of short-answer conceptual questions that are posed to the student as new material is introduced. Instructors can assign these questions, which are graded online, as part of a reading assignment before class. The results can be stored electronically and made available to instructors to inform class preparation. Over the course of a chapter, students will, in effect, have constructed an assessment portfolio based on the results of these conceptual questions.

GF02: 1:10-1:20 p.m. Encouraging Metacognitive Thinking with Exam Wrappers

Contributed – Jeffrey A. Phillips, Loyola Marymount University, Los Angeles, CA 90045; jphillips@lmu.edu

Ideally students use the feedback provided them on a graded test to make adjustments in their study habits, but often they fail to do this since each test is seen as an isolated incident. To encourage metacognitive thinking across tests, students are asked to reflect on the source of their errors and plan strategies for avoiding them in the future. By framing this activity as test corrections, where students can earn back some of their missed points, virtually all of students happily participate. The structure of these wrappers, including strategies for keeping the instructor's workload manageable, will be presented along with sample student work.

GF03: 1:20-1:30 p.m. Study of Informal Learning Communities and its Reflection on Learning

Contributed – Yuehai Yang, California State University Chico, CA 95926; yyang34@csuchico.edu

Binod Nainabasti, David Brookes, Florida International University

We have studied the student social network data collected from the weekly self-reported poll about who works with whom during the whole semester of an algebra-based introductory college physics class. This investigation is seeking understandings about patterns of formation of informal learning communities outside the traditional lecture classroom and which components of the class will enhance the network formation. Our study also analyzes the relationship between students' network positions as they work together in groups outside the classroom with their performance on exams and homework.

GF04: 1:30-1:40 p.m. Problem Solving and "Beginning with the Physical Situation"

Contributed – Dennis Gilbert, Lane Community College, Eugene, OR 97402-4067; gilbertd@lanecc.edu

This presentation elaborates on moving students to "begin with the physical situation" in problem solving and developing conceptual understanding in calculus-based General Physics. A variety of visual tools and interventions in class discourse will be presented, which support students in transforming their approach to problems solving. These diagrams and discourse interventions also provide students tools for greater awareness of their evolving understanding of the nature of science and physics, level of knowing, problem solving, and their identity as physics learners.

GF05: 1:40-1:50 p.m. Open-Ended Problems: Video Analysis by Students

Contributed – Mary M. Brewer, William Jewell College, Liberty, MO 64068; brewerm@william.jewell.edu

Zachary Taylor, William Jewell College

In an attempt to enable students to move beyond standard textbook problems and apply physics concepts to real situations, students in first-semester general physics are given a set of videos to analyze. The videos often show impossible or unlikely situations and students are to draw conclusions about the validity of the videos based upon what they can measure, calculate, and conclude for each situation. Since each situation can be analyzed in different ways and there is no one right answer, students show greater creativity and problem solving skills than with traditional textbook problems.

GF06: 1:50-2 p.m. The Effect of Online Lecture on Performance in a Physics Class

Contributed – John C. Stewart, University of Arkansas, Physics Department, Fayetteville, AR 72701; johns@uark.edu

This talk will examine the difference in student performance between students attending lecture in person and students choosing to watch the lecture on video as part of an online class. The option to watch the lecture on video was implemented mid-semester in fall 2012 so that the performance of the same set of students could be compared. A fully online lecture section was introduced in spring 2013. Higher than expected withdrawal rates have been experienced in the online sections of the class. These will be examined in the context of the historical performance of the class, the demographics of the students, and their motivation for enrolling in the online experience. Differences in time-on-task for online and face-to-face students will also be presented.

GF07: 2-2:10 p.m. Another Look at Elementary but Surprising Facts About Evaporation

Contributed – A. James Mallmann, Milwaukee School of Engineering, Milwaukee, WI 53202-3109; mallmann@msoe.edu

Analysis of easily obtained data made me aware of some facts about evaporation of liquids that surprised me, and may surprise you as well. Those facts inspire questions, problems, and laboratory projects for students of introductory physics courses. I will describe projects that range from those appropriate for general physics students to the more challenging goal of predicting how the temperature of evaporating water depends on time. I will show how that goal can be accomplished by solving a differential equation that is not as easy to solve as the differential equations for simple harmonic motion and the infinite-square-well problem that we typically solve by inspection.

GF08: 2:10-2:20 p.m. Sequencing Kinesthetic Activities to Explore Observation Location

Contributed – Mary Bridget Kustusch, DePaul University, Chicago, IL 60614; mkustus1@depaul.edu

Susan Fischer, DePaul University

There has been growing interest in the use of kinesthetic and embodied learning activities in the classroom. This talk presents a new sequence of previously developed kinesthetic activities, where the sequencing is designed to provide students with multiple opportunities to explore the role of the observation location on electric and magnetic fields. We will also present some preliminary data on the use of this sequence in an algebra-based introductory electromagnetism course.

GF09: 2:20-2:30 p.m. The Mysterious Static Friction

Contributed – Harold T. Stokes, Brigham Young University, Department of Physics, Provo, UT 84602; stokesh@byu.edu

The concept of static friction causes a great deal of trouble for students. They have an especially difficult time determining its direction. I will present a number of clicker quizzes that help students deal with this concept as well as illustrate the type of trouble they experience.

GF10: 2:30-2:40 p.m. Angular Momentum and the Motorcycle Turn

Contributed – J. Ronald Galli, Weber State University, Physics Department, Ogden, UT 84408-2508; jrgalli@weber.edu

The torque from the handlebars that causes the front wheel of a motorcycle to lean and a subsequent torque of gravity that turns the wheel (and therefore the entire motorcycle) is known as counter-steering. This presentation will explain the physics of a typical motorcycle turn. My 4-ball gyro bicycle "wheel" demonstration will be used to explain precession in simple terms.

Session GG: Post-deadline Session I

Location: Tate Lab 133
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1–2:40 p.m.

Presider: Andy Rundquist

GG01: 1-1:10 p.m. Dr. Seuss Made Physics Easy 4 Everyone!

Contributed – Shannon A. Schunicht, Texas A&M, 6773 Bendwood College Station, TX 77845-3005; sschunicht@gmail.com

The study of Physics is overwhelming 2 most everyone! In particular, the non-physicist who has no interest, nor need for further studies. This is particular the case for this author who was involved in a mid-air collision to be rendered unconscious 4 three weeks. Everything had 2 b relearned, as nursing actions were reported as having been displayed upon awakening from the extended unconsciousness (19 days). Studies n recovery brought about a pragmatic discovery 2 compensate 4 the residual memory deficits. In particular, having each vowel:mathematical operation; i.e. a:multiplication => @, o:division => over, i:subtraction => minus, u:addition => plus, & e:equals. Most constants and variables are indeed consonants, e.g. z=altitude, s=reaction rate. Using this mnemonic technique, ANY FORMULA may b made into a memorable work/phrase. ******Upon attendance this author may be spied speaking with a hole in my head, or viewed on this author's web: mnemonicwritings.com. The application of this mnemonic technique 2 Eastern characters has yet 2 b explored. Regardless its academic potential remains limitless as Delta X =>

0. Sample cards with [vowels:Mathematical Operations] will be distributed. Also, it includes alternative equations, as well an area 2 submit any devised acronyms with your name 2 b used n future works.

GG02: 1:10-1:20 p.m. A Low Cost, Yet State-of-the-Art Organic Solar Cell and Light Emitting Diode Fabrication Setup for Undergraduate Teaching and Research Laboratories

Contributed – Alexi C. Arango, Mount Holyoke College, South Hadley, MA 01075-1424; aarango@mtholyoke.edu

A custom-designed research facility at Mount Holyoke College has been built to offer undergraduate students the opportunity to conduct cutting-edge research typically reserved for graduate students at large research universities. The facility provides thin-film deposition capability for the fabrication of organic solar cells and light emitting diodes, a rapidly growing field of research that undergraduate students find particularly appealing. Operating within a modest budget, much of the instrumentation was simplified, reduced in size and uniquely configured in order to enhance user-friendliness, reduce processing times, limit maintenance and reduce noise. A significant fraction of the design work and assembly was carried out by students. Using the completed setup, students are routinely fabricating and testing cells within a two-hour laboratory period. The facility is a striking example of how undergraduate institutions can affordably provide a state-of-the-art research experience.

GG03: 1:20-1:30 p.m. Development of Student Projects to Promote Sustainability

Contributed – Blane Baker, William Jewell College, Liberty, MO 64068-1896; bakerb@william.jewell.edu

Conner Hazelrigg, William Jewell College

As part of a recent effort to incorporate more renewable energy projects into our curriculum, we have partnered with various organizations to identify areas of need in locations such as Haiti and Native American Reservations in the U.S. Once such needs are identified, students and faculty work closely with personnel in those locations to determine appropriate projects for students in our Research Experience course. Two projects completed recently include a portable solar-powered, cell-phone battery charger and a 12 V lighting system for use in a community building. This talk will focus on discussions of designs of these projects as well as some of the experiments performed to test their feasibility.

GG04: 1:30-1:40 p.m. From the Lab to the Class

Contributed – John Branch, Brigham Young University, Provo, UT 84602-0002; johnbranchjr@hotmail.com

Teaching science in K-12 today is usually based on strict guidelines that focus on topics. These topics are usually on some statewide exam (i.e?FCAT, STAAR). With so much onus today on testing, students and teachers often miss out on real-world experiences. I had the opportunity to conduct research as an adjunct faculty member in the Department of Physics and Astronomy at Brigham Young University (BYU). The Research for Teachers (RET) program at BYU allowed me to participate in some hands-on research (some of the results will be presented here) and bring these skills to the classroom in terms of getting students excited about science and participating in future research opportunities down the road.

GG05: 1:40-1:50 p.m. Homework Help Using a Web-based Chat Room with an Equation Editor

Contributed – Daniel E. Beeker, Indiana University, Bloomington, IN 47405; debeeker@indiana.edu

Experiences using an open source online chatroom (mathim.com) with an equation editor (MathType) for online help sessions in a general science course are described.

GG06: 1:50-2 p.m. Peer Grading in a Flipped Classroom and MOOC

Contributed – Scott S. Douglas, 1412 Edgehill Ave., Unit 3, Nashville, TN 37212; scott.s.douglas@gatech.edu

John M. Aiken, Georgia Institute of Technology & Georgia State University

Shih-Yin Lin, Edwin F. Greco, Michael F. Schatz, Georgia Institute of Technology

For our Massively Open Online Course (MOOC) and on-campus “flipped” introductory physics classes, we emphasized peer review and scientific communication as important elements of physics practice; our students prepared several short video lab reports, and we distributed these videos among the students for review. In a flipped classroom, the material traditionally presented during in-class lectures is instead presented online outside of the classroom; in our classes, the laboratory exercises were performed outside of the classroom, too. To facilitate the peer review of video lab reports, we developed an online peer-grading tool called Statistically Weighted Aggregate Peer Review (SWAPR) in fall 2013. To increase the reliability of grades assigned through SWAPR, we developed several methods of weighting students’ responses by comparing student and expert responses to a set of “calibration” assignments. We discuss our statistical analysis of student vs. expert grading and the validity and significance of our calibration methods.

GG07: 2-2:10 p.m. Raising Calculus to the Surface: Engaging Discovery Using Tangible Models

Contributed – Aaron Wangberg, Winona State University, Winona, MN 55987; awangberg@winona.edu

Eric Weber, Oregon State University

Jason Samuels, City University of New York

Brian Fisher, Pepperdine University

The solutions to mathematics and science problems with multiple variables often rely upon the geometric relationships between mathematical objects. For most calculus and stem students, this geometric reasoning occurs after their algebraic understandings ? if at all. This presentation shows a new approach to multivariable calculus which encourages student discovery of the geometric properties of mathematical objects before formal introduction with algebraic expressions. Using tangible models, students are able to discuss the geometric (including coordinate dependent and independent) properties of such mathematical concepts as gradient, directional derivatives, level curves, integrals, and partial derivatives and the role of these concepts in solving contextualized problems.

GG08: 2:10-2:20 p.m. MindMeld: Science and Engineering Competition

Contributed – Remy Dou, Florida International University, Miami, FL 33183; douremy@gmail.com

The idea of taking Physics or other higher science courses in high school intimidates particular students for many reasons. Upon taking a position as science department chair of a medium-sized, private, K-12 institution, I sought to positively influence the student culture towards greater interest in Physics and engineering. Working with fellow teachers, we developed the MindMeld: Science and Engineering Competition. The low-risk competition engaged students from all grade levels, drawing equal participation from males and females. Competition cycles lasted one school year, giving students the opportunity to participate in three major challenges, which included building shoes to walk on water and trebuchets. I also used the competition as a project-based learning component of my Physics classes. The competition contributed to a culture shift across the school, creating more vocal student interest in science courses. In this talk I describe the competition and share anecdotes about its success and limitations.

GG09: 2:20-2:30 p.m. The IceCube Astrophysics MasterClass

Contributed – James Madsen, UW-River Falls, River Falls, WI 54022-5013; james.madsen@uwrf.edu

Silvia Bravo, Wisconsin IceCube Particle Astrophysics Center

The IceCube Collaboration is launching a new educational program that will give high school students the opportunity to learn about neutrinos and what they tell us about the universe while discovering a unique experiment: IceCube, a cubic-kilometer neutrino detector buried in Antarctica's ice. It is based on the highly successful particle physics MasterClass program. High school students, and accompanying teachers, will join IceCube scientists and staff and perform an analysis using IceCube data. They will also meet active physics researchers and will link up with student peers from other countries. The students will be introduced to IceCube through a lecture and then will work on a guided activity to reproduce a recent research result published by the collaboration in science. The students will participate in a web conference with the South Pole and, finally, they will discuss their results in a virtual meeting with other students from across the U.S. and from other countries in Europe. Examples from the MasterClass will be provided.

GG10: 2:30-2:40 p.m. The Physics of a Uniform Gravitational Field

Contributed – Elisha Huggins, Dartmouth College, 29 Moose Mountain Lodge Rd., Etna, NH 03750; lish.huggins@dartmouth.edu

We compare two uniform gravitational fields. One is the repulsive gravitational field created by dark (vacuum) energy that causes the Hubble expansion, the other is in an elevator shaft at Harvard University. Both cause photon redshifts, one in the light from distant galaxies climbing against repulsive gravity, the other in photons sent up the elevator shaft from Glen Rebka at the bottom to Robert Pound at the top. And both redshifts can be explained as resulting from an expansion of space caused by a uniform gravitational field. But these fields are limited in strength. The space between galaxies expands, yet galaxies do not because the uniform repulsive gravity is overwhelmed by stronger forces inside the galaxy. In our analysis of the Pound-Rebka experiment, the space inside the elevator shaft expands, but the building does not because it was designed to support itself against gravity. We also calculate the Hubble times for both uniform fields.

Session GH: Post-deadline Session II

Location: Tate Lab 166
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1– 2:20 p.m.

Presider: Karie Meyer

GH01: 1-1:10 p.m. We Share Solar, a STEM Program to Build a Solar Suitcase

Contributed – Tiberiu Dragoiu Luca, The Hun School of Princeton, 176 Edgerstoune Rd., Princeton, NJ 08540-6799; tdragoiu@gmail.com

We Share Solar is a STEM education program, which uses the building of a We Share Solar Suitcase (a 12V DC Stand-Alone Solar Power System) as a learning platform for solar technology. It is a program that is offered by the parent organization We Care Solar (CNN Hero). The We Share Solar kit (also referring to as Solar Suitcase) was developed to allow teachers to easily have all the necessary parts to build a solar electric system, and to provide a supportive educational program with enriching curriculum in solar energy literacy. In this short talk I will present the implementation of this program at my school.

GH02: 1:10-1:20 p.m. Exploring Five Different Physics Concepts Using Soap Films

Contributed – Swapnil Tripathi, UW-Washington County, West Bend, WI 53095; swapnil.tripathi@uwc.edu

In this talk I will demonstrate how the topic of soap films can be used to teach various important physics concepts in a very engaging and novel way. I will discuss many experiments and demonstrations that will capture students' interest and can be performed with a moderate effort. Some advanced applications of soap films in science and engineering solutions will also be discussed.

GH03: 1:20-1:30 p.m. A Dissociated, Progressive Introductory Physics Laboratory

Contributed – Bruce Thompson, Ithaca College, Department of Physics and Astronomy, Ithaca, NY 14850; bthompso@ithaca.edu

I am the current caretaker and reviser of an introductory mechanics laboratory in the first-year curriculum at Ithaca College. Substantial revisions since its inception in the 1980s have created a coherent laboratory experience that alumni remark upon as having continued relevance in their careers. The course is dissociated because students take it in the semester following their introductory mechanics course. It is progressive because multiple themes and skills are developed and refined over the course of the semester. Some of these themes are: logical thinking (digital circuit analysis, trouble shooting, raw data evaluation), dexterity skills (circuit wiring, Erector Set skills), physics (linear kinematics, pendular motion and energy, rotational dynamics), modeling (increasing sophistication in linearized modeling and model verification), analysis (linear graphical analysis by hand, min/max error propagation, spreadsheet calculation and graphing), communication (binary reporting, summary reports, extensive report). I will present an overview of the course.

GH04: 1:30-1:40 p.m. Learning: Two Steps Forward, One Step Back

Contributed – Nathaniel Lasry, John Abbott College, Hampstead, QC H3X 3A2 Canada; lasry@johnabbott.qc.ca

Eric Mazur, Harvard University

Jonathan Guillemette, John Abbott College

Previous work on how students change conceptions in introductory physics courses has focused on conceptual gains without taking losses into account. We analyze Force Concept Inventory data collected before and after an introductory course for 13,422 students learning physics in high schools, two-year colleges, public universities and elite universities. When looking at individual answers, we argue that current gain metrics are only valid under the assumption that there are no losses. Across all students, we find mean losses of 30%, with little fluctuation from this value in all institutions except in elite universities (15%). This suggests that conceptual losses are important and that conceptual trajectories may be described as two-steps forward, one-step-backward. The instability of initially correct responses also provide more support for the resources model (positing conceptions as flexible and context-dependent) than for the misconception model (positing conceptions as deeply rooted and resistant to change). For conceptual assessments, we propose replacing current one-dimensional gain measures - that average over gains and losses- by a three-dimensional metric that reports students initial knowledge state and accounts both for gains and losses.

GH05: 1:40-1:50 p.m. Flux and Divergence with an Overhead Projector

Contributed – Robyn L. Wangberg, St. Mary's University of Minnesota, Winona, MN 55987; rwangber@smumn.edu

Aaron D. Wangberg, Winona State University

The idea of flux and the connection between divergence and flux is often confusing for students. We designed an activity that lets students discover properties of flux and divergence using light from an overhead projector and a piece of thin, flexible Plexiglass. The activity provides opportunities to challenge students' conceptions and ultimately leads them to the divergence theorem with a visual aid.

GH06: 1:50-2 p.m. Inexpensive Equatorial Mount Design for Medium-sized Telescopes

Contributed – Mark W. Jacobs, Northern Michigan University, Physics Department, Marquette, MI 49855; mjacobs@nmu.edu

An equatorial mounting simplifies some astronomical imaging, but commercial options for telescopes used at small universities and some high schools (say 12 to 16 inch apertures) can be expensive. I describe a simple design that is relatively inexpensive, easy to build, adaptable, and that has given good results. Students can be meaningfully involved in both design and fabrication. The design gives good examples of basic concepts like torque and center of mass, while the fabrication can be done using sheet steel and standard metal shop equipment.

GH07: 2-2:10 p.m. Complementarity in Teaching Revisited: Experiencing and Explaining the Tension

Contributed – Jared R. Stenson, Rice University, Houston, TX 77005; stenson@rice.edu

This presentation revisits a talk I gave at a National AAPT meeting entitled "Complementarity in Teaching: Answering Questions and Questioning Answers." At that time I was a young, inexperienced graduate student. Now, nearly 10 years later, I have experience teaching at community colleges and universities, public and private, large and small, focused on teaching or on research, teaching individually and in teams. These mutually exclusive but complementary experiences have reemphasized this theme as I have struggled to incorporate research-based methods into traditional environments. In this talk I will discuss this pedagogical tension in the context of Kuhnian paradigms while addressing epistemic beliefs, faculty approaches, curricular choices, logistical realities, and educational goals. Just as with its quantum counterpart however, this complementarity leaves us in the end with increased insight and a few more useful ideas but also with a better recognition that ambiguity is deeply rooted in the system.

GH08: 2:10-2:20 p.m. A Virtual Quantum Research Lab to be Explored by Undergraduates

Contributed – Mathias Tomandl, University of Vienna, Boltzmanngasse 5 Vienna, 1090 Austria; mathias.tomandl@univie.ac.at

Christiane M. Losert Valiente-Kroon, Martin Hopf, Markus Arndt, University of Vienna

We introduce a new technology-enhanced learning tool for modern experimental physics—the Simulated Interactive Research Experiment (SIRE) —which is used and evaluated in an undergraduate quantum lab course: The SIRE prototype is a complex and interactive simulation of an existing research experiment on matter-wave interference with macromolecules, driven by extensive and scientifically valid simulations of the experimental results. This also includes measurement artifacts and experimental limitations of the setup. Students can thus be trained in advanced modern experimental physics using state of the art learning tools. Many physics curricula provide courses on current research topics only in advanced semesters. SIREs open possibilities for active and curiosity-driven learning also to undergraduate students. Similar to a flight simulator, SIREs allow the students to manipulate all the relevant parameters in the experimental setup. They can control and interact with phenomena and experimental equipment that would otherwise be inaccessible outside of specialized research labs.

Session GI: Post-deadline Session III

Location: STSS 114
Sponsor: AAPT
Date: Wednesday, July 30
Time: 1– 2:30 p.m.

Presider: Mike Gallis

GI01: 1-1:10 p.m. Alliance for Physics Excellence (APEX) at Alabama A&M University

Contributed – Barbara B. Cady, Alabama A&M University, Huntsville, AL 35811; bbcady@aol.com

Vernessa M. Edwards, Marius P. Schamschula, Mohan D. Aggarwal, Alabama A&M University

The Alliance for Physics Excellence (APEX) at Alabama A&M University, a partnership project funded by NSF and composed of state-wide agencies and institutions designed to improve secondary physics teaching in Alabama, will present challenges and successes of a state-wide transformation in physics teaching. As the second year of a five-year project is nearing completion, preliminary results are showing quantitative and definitive qualitative changes in attitudes, beliefs, and actions of in-service secondary teachers of physics. Vignettes from summer and academic year workshops and action research classroom activities will highlight the integrated approach of discipline content with pedagogical content knowledge as well as technological knowledge and skills into a theoretical innovative teaching model. Funded by NSF DUE-MSP targeted project 1238192 Project URL: http://apex.aamu.edu

GI02: 1:10-1:20 p.m. Whose Reality Are We Augmenting? Exploring Students' Own Experiences

Contributed – Victoria Winters, New York Hall of Science, 47-01 111th St., New York, NY 11368; vwinters@nysci.org

Laura Rodriguez-Costacamps, Talya Wolf, Harouna Ba, New York Hall of Science

Physics teachers have a long history of creating and employing digital tools to help students explore physics concepts and get excited about science. In this presentation, we review the common roles that digital tools play in physics learning and instruction, focusing on technologies that capture static or dynamic representations of the world and augment them by layering on scientific information, either in real-time or for later investigation. While many digital tools involve a carefully designed ideally behaving world or provide high resolution video of perfectly executed demos, we argue that there is value in tools that allow students to capture and explore their own physical experiences. We discuss the benefits and drawbacks to enabling students to digitally document and investigate their own experiential reality, informed by our ongoing development of a digital app that empowers middle school students to explore the energy, forces, and motion of their own playful performances.

GI03: 1:20-1:30 p.m. The Multipole Expansion of the Electric Potential and Non-Spherical Nuclei

Contributed – John Karkheck, Marquette University, Milwaukee, WI 53201-1881; John.Karkheck@marquette.edu

The multipole expansion of the electric potential, developed in electrostatics, is a powerful tool for elucidating relationships between shape of electric fields and geometric symmetry of charge distributions. In standard texts, thorough development is given for the first two terms, the monopole and dipole terms. The third term, the quadrupole term, is analytically tractable in symmetric situations such as ellipsoids of revolution which serve as fruitful models for employing the quadrupole moment of non-spherical nuclei to estimate nuclear dimensions. A standard analysis found in nuclear-physics texts employs the assumption that deviations from sphericity are small, a condition that often does not hold. The approach here, based on the assumption of shape-independent nuclear density, results in an exactly solvable cubic equation for the semi-major axis. Comparison is given of results from the two approaches.

GI04: 1:30-1:40 p.m. Strategies for Effective Use of DyKnow Software and Tablet PC Technology in Introductory Physics

Contributed – Jason Stecklein, Clarke University, Dubuque, IA 52001; jason.stecklein@gmail.com

The utilization of emerging forms of technologies will affect learning in science classrooms of the future. Though technology has emerged in many forms, its effective employment in university science classrooms has lagged behind the rapid development of new constructivist pedagogies. Enlistment of instructional technologies in student-centered environments offers distinct opportunities, such as providing teacher feedback to students and permitting effective scaffolding of classroom activities. Results of a qualitative case study of three university students taking introductory physics in a technology-enhanced setting will be discussed. These results indicate that ad hoc use of instructional technologies, like DyKnow Software and tablet PCs, is not enough for effective learning. Purposeful teacher strategies are essential for student construction of knowledge, including (1) instituting a proper climate for technology use and (2) utilizing intentional teacher scaffolding of activities to increase student interactions, expose student ideas to modification, and provide immediate teacher feedback to those ideas.

GI05: 1:40-1:50 p.m. Squishy Capacitor Model of Charged Interfaces: Negative Capacitance, Phase Transitions

Contributed – Michael B. Partensky, Rabb School, GPS, Brandeis University, Waltham, MA 02453; partensky@gmail.com

The most common and natural component in the equivalent circuit of electrical double layers (EDL) is the electric capacitor C. First introduced by Helmholtz and further developed in numerous theoretical treatments, the EDL capacitor models allowed to understand properties of charged interfaces in chemistry, biology, plasma physics. The majority of EDL theories are based on the assumption of lateral uniformity, e.g. the studies of uniformly charged electrode in contact with electrolyte. The fascinating question raised in such studies is the possibility of negative capacitance (NC) in EDL or in its components. The issue of NC became especially important recently in applications to various nano-devices. We discuss the relation of EDL's NC to surface instabilities and phase transition. The adequate electro-mechanical model should allow for lateral non-uniformity of C (transition to a non-uniform state). We discuss the "squishy capacitor model" to demonstrate various types of surface instabilities and phase transitions related to NC.

GI06: 1:50-2 p.m. Small Coordinated Cooperative Groups for Solving Homework

Contributed – Thomas Gredig, California State University Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-9505; thomas.gredig@csulb.edu*

Zvonimir T Hlousek, Chuhee Kwon, California State University Long Beach

Micro-communities or group work has had a long tradition in physics courses starting in the 1970s. Generally, it has been found that teamwork contributes to more efficient student learning, if it is properly structured. The structure, however, is crucial, as otherwise teamwork is not useful. Here, we discuss how structured cooperative micro-communities can be implemented using asynchronous web technologies to foster interest and encourage critical thinking and problem solving. One particular example involves introductory physics students solving complex numerical problems that would be demanding for a beginner to approach, but can be solved with the help of a peer group. This method enables introductory students to explore real world phenomena by modeling them with the abstract concepts learned in class. This work has been supported by the Chancellor's Office of the California State University through Gerry Hanley.

*Sponsored by Chuhee Kwon

GI07: 2-2:10 p.m. Preparing Students for Experimental Research

Contributed – Gregory Pawloski, University of Minnesota, Minneapolis, MN 55455; pawloski@physics.umn.edu

Physics majors are exposed to numerous classes that provide a theoretical foundation. In addition many courses offer laboratory components with predefined projects that give the students a chance to develop basic data collection and analysis skills. However, opportunities for the students to formally develop professional research skills in which they confront problems without predefined solutions are often limited. At the University of Minnesota, we offer a capstone course in which the students undertake a research project that reflects the structure of an actual research environment. We require that each student undertakes a literature search to find a physical problem that can be experimentally studied, propose, design, and execute an independent experimental project to address that problem. I will discuss the pedagogy of this course and how we balance letting the students develop an independent and open-ended research project with pragmatic limitations of resources, time, and experimental feasibility.

GI08: 2:10-2:20 p.m. InquirySpace: Powerful, Free Software for Collecting, Analyzing and Modeling Data

Contributed – Chad Dorsey,The Concord Consortium, Concord, MA 01742; cdorsey@concord.org

Wish your students could collect and analyze data all in one place? Want to analyze data from models and simulations as well as from probes and sensors? Come learn how powerful new NSF-funded software from the Concord Consortium can enable all this and more. The "missing link" for modeling-based approaches and perfect for anyone collecting and exploring data, InquirySpace provides free, open source tools that greatly expand the range and sophistication of meaningful open-ended science investigations. InquirySpace integrates three proven technologies—real-time data collection from probes and sensors, the versatile modeling environments of NetLogo and the Molecular Workbench, and the powerful visual data exploration capabilities of the Common Online Data Analysis Platform (CODAP), based on Fathom and Tinkerplots and integrates them into a coherent, Web-based environment enabling rich, collaborative scientific inquiry. Come learn about the power of this tool and how you can access it for free today.

GI09: 2:20-2:30 p.m. Beyond the Flipped Classroom: Student Generated Multimedia Learning Objects

Contributed – Firas Moosvi, University of British Columbia, Department of Physics and Astronomy, Vancouver, BC V6t1Z1 Canada; Firas@moosvi.com

Joss Ives, Georg Rieger, Simon P. Bates, University of British Columbia

Results and implementation details from a novel learning approach that extends the pedagogy of the Flipped Classroom (FC) is described in this study. Students in a large introductory physics class (N=805) were tasked with the creation of two learning objects (LOs) over the course of the term based on pre-reading material set for the whole class. An experienced TA screened the LOs for quality and relevance to the course with the best ones highlighted and incorporated into the lectures and tutorials. Implementation strategies that helped ensure a consistent submission rate over the course of the term spanning all topics are discussed. With a participation rate of over 80%, students appeared engaged and interested in the LO exercise and self-reported dramatic improvements in their understanding of the content based on a five-point scale despite the presence of many other assigned items in the course.

Session PST2G: Post-deadline Posters

Location: Coffman Union ground floor
Date: Wednesday, July 30
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 may be set up starting at 8 a.m. Wednesday and then should be taken down by 2:30 p.m. Wednesday)

PST2G01: 1-1:45 p.m. Facilitating an Authentic Research Experience in Quantitative Biology and Biophysics

Poster – Benjamin Geller, University of Maryland College Park, Department of Physics, College Park, MD 20742; geller@umd.edu

Patrick Killion, Wolfgang Losert, Chandra Turpen, University of Maryland College Park

The First-Year Innovation and Research Experience (FIRE) aims to facilitate transformational experiences for first-year undergraduates in faculty-led research and innovation streams at the University of Maryland, College Park. A pre-pilot FIRE stream was implemented during the spring 2014 semester, focusing on authentic biophysical research questions related to the dynamics of the cytoskeletal network and the associated motor proteins. More broadly, this stream provided students (1) the opportunity to develop research skills that make them competitive when applying for future research internships and/or medical school, (2) iterative practice in written and oral scientific communication, and (3) the chance to build a collaborative and supportive community that lasts beyond the end of the stream.

PST2G02: 1:45-2:30 p.m. Flipping the Introductory Physics Classroom

Poster – Joseph J. Trout, Richard Stockton College of NJ, Philadelphia, PA 19130; troutj2@stockton.edu

Assessment was completed on using classroom "flipping" techniques and this assessment will be presented. The "flipping" techniques include using in-class group assignments and video lectures. Self assessment by student surveys will also be presented.

PST2G03: 1-1:45 p.m. Music Science Collaboration: Libraries, Community Band, and Music Education Students

Poster – Patricia Sievert, Northern Illinois University, NIU STEM Outreach, De Kalb, IL 60115; psievert@niu.edu

Engagement and collaboration produce rich physics outreach experiences. This year we collaborate with three area libraries, the School of Music, additional NIU faculty and students, and the oldest, continuously performing community band in the United States to bring the physics of music to families across our county. A simulcast performance and music-physics demonstration with musicians at three libraries and on campus kicks off this spring's series. A local artist and environmental studies education students will team up with us to help families recycle materials into instruments for Earth Day. An art educator and a sound technician from our e-learning lab will team up with us to work with families in a circuit-bending activity to produce electronic instruments from old toys in May. The finale will be a family music-science fair immediately preceding the first summer concert of the DeKalb Community Band as it kicks off its 160th season. www.niu.edu/stem

PST2G04: 1:45-2:30 p.m. Stimulating Research-driven Reforms – The Role of Concept Inventories

Poster – Vijay Singh, HBCSE, TIFR Mumbai, IN 400088; mashoodkk123@gmail.com Mashood KK*

Science education research is a nascent area of academics in India. However the country has a vast and aspiring student population. Quality science education is thus extremely vital for the economic and societal progress of the country. We have been involved with the task of promoting research in science education, particularly at the introductory level. We chose concept inventories as a means to facilitate as it enables large-scale application. It may be noted that CIs played a crucial role in stimulating reforms in the U.S. inspired us. In this paper we present some of the work we carried out in this regard. We developed inventories on friction on rolling bodies and rotational kinematics of a rigid body. We administered popular inventories such as the Force Concept Inventory and the Conceptual Survey of Electricity and Magnetism to Indian students. We compare our results with those of the U.S. and China. The Kuder Richardson reliability index for FCI for a sample of over 900 students was 0.95. On the other hand CSEM registered a value of 0.96 for a sample of nearly 500 students. We are also involved in training motivated practicing teachers to develop their own inventories on introductory level topics.

*Sponsored by: Dr. Ravi K Menon

PST2G05: 1-1:45 p.m. The Formality of Physical and Social Sciences Learning.

Poster – Mario Humberto Ramirez Diaz, IPN Legaria 694, Mexico, MEX 11500 Mexico; echavezl@ipn.mx

Eduardo Chávez Lima, ESCOM-IPN

When considering physics as a nomothetic and generalizing science, which is isolated from the ideographic sciences or individualized sciences, can not display the opportunity to take formal models that serve to give a widening in this construct. Currently interdisciplinarity and multidisciplinarity allows us to cooperate between different branches of science, even create new sciences like Sociophysical and Econophysics, which occupy the same models. This requires us to share in a classroom, the construction of these branches of knowledge with a mixture of teaching physics, grounded in models that support a political, economic and cultural baggage.

PST2G06: 1:45-2:30 p.m. Data Collection on Cirrus Coverage Using an Allsky Camera

Poster – Sylke Boyd, University of Minnesota-Morris, Morris, MN 56267; sboyd@morris.umn.edu

Shelby Richards, Jieying Jin, University of Minnesota-Morris

Systematic observations of atmospheric optical phenomena can reveal much about the physical properties of normally inaccessible layers of the troposphere, for example at cirrus altitude. Optical displays are influenced by the ice crystal shapes, sizes, orientations, and particle densities. This research aims to utilize these optical phenomena for remote probing of atmospheric conditions that affect the color, angular intensity distribution, brightness, and type of optical displays, including halos, parhelia, and pillars. An allsky camera serves for long-term observation and data collection on frequency, seasonal distribution, and type of optical displays at the University of Minnesota-Morris. We present our work on image analysis software for the automatic detection of the presence of common halo-related optical phenomena. In addition, we present our work on the development of a simulation aiming to correlate the observed angular intensity distribution with the types, sizes and orientations of ice crystals present in the generating layer.

PST2G07: 1-1:45 p.m. Re-Thinking the Teaching of Intermediate Electrodynamics

Poster – James D. Dull, The College of Idaho, Caldwell, ID 83605; jdull@collegeofidaho.edu

The "flipped" classroom teaching model makes lecture-like information available outside the classroom, and then builds on this instruction through learning activities such as group problem solving, discussion, and short projects. This differs from the traditional lecture/homework model by requiring students to enter the classroom prepared to learn. I have adopted a more modest version of the flipped classroom. Reading the text is used in a way similar to lecture videos, and students are rewarded for and challenged to complete reading and short assignments in preparation for group problem-solving sessions during each class period. This no-lecture classroom, emphasizing a more dynamic form of communicating conceptual and detailed understanding through written and oral assignments, was eagerly adopted by my students. In addition, preliminary comparisons with the results from more traditional versions of this course show a slight improvement in average test scores. More significantly, this method has given opportunities for the less confident student to demonstrate her/his understanding in multiple formats.

PST2G08: 1:45-2:30 p.m. Twitter as a Professional Development Tool for Physicists

Poster – Eric C. Martell, Millikin University, Decatur, IL 62522;emartell@millikin.edu

Social media is ubiquitous in popular culture and is used by individuals and businesses to build a brand and interact with customers, but it is much more than a repository for advertising and banal statements about the state of an individual's lunch choices. Twitter, in particular, can be used to develop professional connections, share news regarding research and teaching, and collaborate with colleagues around the world in real time. This can be especially important for faculty teaching in smaller departments, where the opportunities for professional interactions with diverse colleagues are limited, although physicists from departments of all sizes can benefit from effective use of Twitter.

PST2G09: 1-1:45 p.m. Using IOLab to Correct Student Misunderstandings of Newton's Third Law

Poster – Eric C. Martell, Millikin University, Decatur, IL 62522;emartell@millikin.edu

Nicole Tipsword, Millikin University; Mats Selen, University of Illinois, Urbana-Champaign

The Force Concept Inventory (FCI) is used at schools across the country as a tool to measure student conceptual understanding of Newtonian physics. One of the weaknesses commonly identified is in applications of Newton's Third Law. In this project, we utilized a recently-developed wireless data acquisition system, the IOLab, to attempt to rectify student misunderstandings regarding the Third Law. The subjects for this research came from calculus and algebra-based introductory physics courses. An assessment of the effectiveness of this teaching tool as well as a comparison between the two courses will be included.

PST2G10: 1:45-2:30 p.m. Fermat's Principle in Refraction of Light

Poster – Vernessa M. Edwards, Alabama A&M University, Normal, AL 35762-1357; vernessa.edwards@aamu.edu

Raj Surabhi, Arjun Tan, Alabama A&M University

Fermat's principle represents a unification of the laws of geometrical optics, namely, the laws of rectilinear propagation, reflection, and refraction. Apparent violations of Fermat's principle have been widely publicized in reflection of light inside ellipsoidal mirrors. This study explores the violation of Fermat's principle in refraction. The surface of separation of the two media is found to be an oval, whose parametric equation is obtained. The part of the oval on which actual refraction could take place is determined. If the oval at any point is replaced by a convex surface having a curvature greater than that of the oval, then the optical path is shown to be maximum. However, since the laws of reflection or refraction are valid at points where the surfaces are locally flat, Fermat's principle of minimum optical path is also obeyed at those same points.

PST2G11: 1-1:45 p.m. A Program for STEM Scholarship Recipients in Physics, Math, Computer Science, and Engineering

Poster – Mary L. Lowe, Loyola University Maryland, Physics Department, Baltimore, MD 21210; mlowe@loyola.edu

Mili Shah, Roberta Sabin, Loyola University Maryland

This poster will focus on the activities at Loyola University Maryland associated with an NSF grant to provide scholarships to STEM undergraduates attending the university from 2007-2012. The poster will describe issues with implementing such a grant: recruitment and selection of students, financial considerations, students' progress through the program, mentoring, research and outreach activities of the recipients, supplemental courses, and retention. Alumni information is now becoming available. Outcomes of physics students who received scholarships will be presented.

PST2G12: 1:45-2:30 p.m. We Share Solar – A STEM Program to Build a Solar Suitcase

Poster – Tiberiu Dragoiu Luca, 176 Edgerstoune Rd., Princeton, NJ 08540-6799; tdragoiu@gmail.com

We Share Solar is a STEM education program, which uses the building of a We Share Solar Suitcase (a 12V DC Stand-Alone Solar Power System) as a learning platform for solar technology. It is a program that is offered by the parent organization We Care Solar (CNN Hero). The We Share Solar kit (also referring to as Solar Suitcase) was developed to allow teachers to easily have all the necessary parts to build a solar electric system, and to provide a supportive educational program with enriching curriculum in solar energy literacy. In this short talk I will present the implementation of this program at my school.

PST2G13: 1-1:45 p.m. Interaction of Negative Ions with X-Rays

Poster – Ileana Dumitriu, Hobart and William Smith Colleges, 10 St. Clair St., Geneva, NY 14456; dumitriu@hws.edu

Candace Carducci, Joshua Moss, Hobart and William Smith Colleges

Clusters are the bridge between gas phase and solid phase and have been studied using mostly laser techniques. Investigation of cluster negative ions using synchrotron radiation is a novel direction. Studies of ionic clusters allow us to understand the complex behavior of bulk materials. The experiment was performed at Lawrence National Berkeley Laboratory, Berkeley, CA. The negative small carbon clusters Cn^{-} (n = 1,?,10) were produced by a cesium sputter source SNICS. The negative ion beam and counter propagating photon beam overlap in the interaction region. Inner-shell photodetachment from negative ions followed by Auger decay produce positive ions that are detected as a function of photon energy. The inner-shell photodetachment cross section of small carbon clusters was measured in the photon energy range of 25 -90 eV. The poster presents experimental results on the size evolution of the electronic properties of the small Cn^{-} (n = 1,?,10) clusters.

PST2G14: 1:45-2:30 p.m. Student Mental Model as a Guide to Teaching

Poster – Anita Roychoudhury, Purdue University, West Lafayette, IN 47907-2040; aroychou@purdue.edu

Nicole Strickhouser, Jefferson High School

Andrew Hirsch, Daniel Shepardson, Devdutta Niyogi, Purdue University

Students develop their mental models from their everyday experiences. It is likely that middle and high school students have developed their mental models of abstract concepts like greenhouse effect and climate change from frequent talks on these topics in the media. Student mental models are personal and are often different from the conceptual models constructed by scientists and the general goal of teaching is to assist students to modify their personal models into the scientific ones. This process is far from a replacement of one by the other; it is a slow process of construction. We will present our iterative findings from the ways student models guided our lessons and how they changed after instruction on greenhouse effect and climate change.

PST2G15: 1-1:45 p.m. SciPlay's Physics Noticing Tool (PNT): Designing for Real Middle School Classrooms

Poster – Laura Rodriguez-Costacamps, New York Hall of Science, 47-01 111th St., Queens, NY 11368; lrodriguez@nysci.org

Victoria Winters, Harouna Ba, Alyssa December, Talya Wolf, New York Hall of Science

The New York Hall of Science's SciPlay department creates and researches technologies and curricular approaches that leverage children's natural playfulness for scientific inquiry and engagement. We recognize the challenge of successfully and simultaneously fostering playfulness and physics learning in the middle school classroom, and are developing a Physics Noticing Tool (PNT) in an effort to support teachers in this endeavor. The PNT is a digital app that allows students to document their own playground activities and investigate the energy, force, and motion involved in their performances. We will discuss how the app design accommodates the messiness of real playground physics, how the accompanying curricular scaffolding addresses the challenges of classroom management, and how the technology and facilitation together can support collaborative classroom investigations of rich and relevant physics.

PST2G16: 1:45-2:30 p.m. Projectile Motion In-class Activity Using Landmarks and Online Map Data

Poster – Kenneth M. Purcell, University of Southern Indiana, Evansville, IN 47712-3596; kmpurcell@usi.edu

Projectile motion is the primary means of discussing two-dimensional kinematics under constant acceleration and is one of the first core concepts encountered by students in an introductory physics course that allows them to develop their problem solving skills. We will discuss a projectile motion activity challenge that we have introduced to keep the interest of the students peaked during the in-class problem solving. Students are broken up into teams and choose a location from a list of chosen landmarks/locations in Evansville, IN. Each team has three "guns" at their base: a fixed angle and adjustable velocity cannon, a fixed velocity and adjustable angle cannon, and a cannon with fixed angle and velocity but an adjustable height. We will also discuss how data from online map sources can be used to obtain accurate distances between preselected landmarks of the instructors choosing.

PST2G17: 1-1:45 p.m. MyTech: Using Smartphones in Physics Labs

Poster – Colleen B. Lanz, North Carolina State University, Raleigh, NC 27695; cblanz@ncsu.edu

Michael A. Paesler, William R. Sams, North Carolina State University

The common use of "black boxes" in physics laboratories impedes students' learning of the topics at hand and the high cost of the equipment often prohibits universities from being able to provide a laboratory experience to their students. We believe that the use of unfamiliar equipment encountered in the laboratory places a pedagogical barrier between students and their educational gains. By using their own familiar electronic devices, students not only gain access to all of the necessary sensors for data collection, but the connection between their school lives and personal lives strengthens. In response to this desire to integrate smartphones into laboratories, we have developed a suite of experiments and apps featuring the use of students' own equipment in data collection and analysis. We will present preliminary results on shifts obtained in kinematics skills, attitudes and technological anxiety from this study to illustrate the impact of smartphones in physics labs.

PST2G18: 1:45-2:30 p.m. Maxwell's Equations in a Plastic Cup

Poster – Gregory W. Putman, Kent State University, Department of Physics, Kent, OH 44242; gputman1@kent.edu

Elizabeth K. Mann, Kent State University

Physics in Entertainment and The Arts Lab is a science core course that serves approximately 500 non-science students per year. This course is designed to explore the physics of everyday objects with a few basics ideas and minimal technical equipment. We focus on waves of sound and light and how they shape music and the visual arts. One of the most appreciated labs involves making a speaker out of a coil of wire, a plastic cup, and a magnet (after using the coil and magnet to explore the relationship between electricity, magnetism and motion.) This activity fascinates students at all levels, including faculty. To paraphrase one student ?Heavy Metal out of a plastic cup is (amazing)!?

PST2G19: 1-1:45 p.m. Investigating Polymer Lens Formation Using Interfacial Liquid Surfaces

Poster – Mason F. White, Carleton College, Northfield, MN 55057;. whitema@carleton.edu

Charlottes M. Zimmerman, Martha E. Baylor, Carleton College

In this experiment we examine the profile of polymer lenses formed by dropping hydrophobic, photo-curable monomer onto liquid substrates, and then solidifying the monomer through exposure to a UV light source. The intermolecular forces acting on the monomer at the interface of these two substances mold the floating monomer into a specific shape. This geometry is maintained as the polymer cures, thus indicating that these intermolecular forces determine the structure of the lens. By manipulating these forces, we can create polymer lenses of different curvatures. We can change the force at the interface by altering the temperature, density, and polarity of the substrate, as well as the container in which the curing process occurs. We will present data for the full width at half max of the lenses with respect to these variables, with the ultimate goal of finding a mathematical equation that describes this curvature.

PST2G20: 1:45-2:30 p.m. History of Nuclear Physics: From the Dawn of Nuclear Physics to the First Atomic Bombs

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

Stephen J. Woolbright, Jacob P. Schumacher, Erskine College

Here we present a fresh look at the major discoveries leading to nuclear fission within the historical perspective. The focus is on the main contributors to the discoveries in nuclear physics, leading to the idea of fission and its application to the creation of the atomic bombs used at the end of the World War II. This work is a more complete review on the history of the nuclear physics discoveries and their application to the atomic bomb. In addition to the traditional approach to the topic, focusing mainly on the fundamental physics discoveries in Europe and on the Manhattan Project in the United States, the nuclear research in Japan is also emphasized. Along with that, a review of the existing credible scholar publications, providing evidence for possible atomic bomb research in Japan, is provided. Proper credit is given to the women physicists, whose contributions had not always been recognized. Considering the historical and political situation at the time of the scientific discoveries, thought-provoking questions about decision-making, morality, and responsibility are also addressed. We refer to the contributions of over 20 Nobel Prize winners.

PST2G21: 1-1:45 p.m. Computational Modeling of Missense Mutations

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

Christopher Henry, Erskine College

Zhe Zhang, Clemson University/ Oak Ridge National Laboratory

The present research is motivated by the global impact of drug dependence and substance abuse, accounting for one of the highest mortality tolls worldwide. We apply biophysics, bioinformatics, and molecular modeling approaches to the recently crystallized structure of the μ-opioid receptor (MOR), which is a member of the GPCR superfamily and one of the primarily targets for opioids. We investigated the impact of four missense mutations in MOR, coded by non-synonymous single nucleotide polymorphisms (nsSNPs), observed in patients with substance dependence problems.

PST2G22: 1:45-2:30 p.m. CERN Beamline for Schools Proposal: Testing Nuclear Cladding Materials

Poster – Emily R. Koss, Glenbrook North High School, Northbrook, IL 60062-6700; EmilyRKoss@gmail.com*

Benjamin Hunt, Julia R. Masterman, Lars E. Stolpe, Michael D. Zhang, Glenbrook North High School

CERN has sponsored the Beamline for Schools competition. Proposals to use their 10 GeV target facility were solicited from international high school student teams. The objective of our experiment is to revolutionize the nuclear energy industry's current testing methods for nuclear reactor cladding materials. Because charged particle beams are more common, less expensive to operate, and allow for faster test cycles than test reactors, our method of using charged particles to simulate neutron damage could expedite testing cycles and reduce development costs.

*Sponsored by Nathan A. Unterman, Glenbrook North High School, Northbrook, IL.

PST2G24: 1:45-2:30 p.m. Agile Development of a Python-based Image Analysis Tool

Poster – Matthew W. Craig, Minnesota State University, Moorhead, 1104 7th Ave. S Moorhead, MN 56563-2996; mcraig@mnstate.edu

A tool for performing professional-level analysis of astronomical images was developed with active undergraduate participation as part of an agile software development process. This poster will provide an overview the ipython notebook-based software. It will be used as the primary tool in an astronomical image processing course. It will also be used by small groups of students in an introductory astronomy course as part of observation projects for the course. Development of the tool will continue in response to student feedback.

PST2G25: 1-1:45 p.m. Tapping Into the Matrix

Poster – Christopher D. Porter, The Ohio State University, Physics Department, Columbus, OH 43210; porter.284@osu.edu

Andrew Heckler, The Ohio State University Physics Department

We present a scaffolded, stepped-complexity approach to incorporating matrices in quantum mechanics at the advanced undergraduate level. Advances have been made in recent years in improving students comfort level with basis vector and/or bra ket notation. But we have observed a disconnect when topics combine matrix notation and linear algebra with traditional wavefunction notation and calculus. This difficulty is notably present in perturbation theory and topics in continuous media. We are developing trial activities that establish a connection between the two notations and concepts, implement increasing levels of complexity as the connection is developed, and finally allow the student to do full calculations and give conceptual interpretations of problems involving both matrix and wavefunction representations. Examples are shown in perturbation theory and continuous media. We comment on early reactions although statistics are not yet available. Currently, the activities have only been used in pilot study for Master's-to-PhD bridge program participants.

PST2G26: 1:45-2:30 p.m. Students' Responses to Different Translations of the Physics Concept Inventory

Poster – Michi Ishimoto, Kochi University of Technology, Tosayamada-cho Kochi, Non U.S. 782-8502 Japan; ishimoto.michi@kochi-tech.ac.jp

The physics concept inventory has "gone global:: It has been translated into many non-English languages and is in use in many countries today. Two Japanese translations of the Force and Motion Conceptual Evaluation (FMCE) by two independent translators differ in terms of their representational and writing styles. In this study, data from 130 Japanese university students who had written both tests were analyzed to detect any differences in the item response ratios caused by different translations. The item response ratios of each test showed statistically significant differences on some distractors between the two tests. This study also examined if experienced physics teachers could predict the differences in the item response ratios between the two tests. The results revealed that the teachers' predictions did not match the data, thus their reasoning could not account for the differences.

PST2G27: 1-1:45 p.m. Physics in the Mountains

Poster – Enrique A. Gomez, Western Carolina University, Cullowhee, NC 28723; egomez@email.wcu.edu

Kelley Dinkelmeyer, Laura Cruz, Freya Kinner, Western Carolina University

We conducted a study of student responses to a "flipped" course for two sections of an introductory, algebra-based, college physics course. In a flipped course, content is presented in online videos introducing physics concepts and the subsequent classroom meeting time is dedicated to solving physics problems both numerical and conceptual. We coupled this flipped course with an additional redesign element where students took field trips to sites in the mountains of Western North Carolina illustrating the application of physics concepts. We collected student responses with three instruments: the Force Concept Inventory, an attitude toward physics survey, and a small group analysis. In the three instruments we find significant shifts in student attitudes toward physics as well as evidence of metacognition.

PST2G28: 1:45-2:30 p.m. More Mathematics in a Conceptual Physics Course: Formula Appreciation Activities

Poster – Vazgen Shekoyan, 43-11 220th Place, Bayside, NY 11361; vshekoyan@qcc.cuny.edu

Conceptual physics courses are typically offered to non-science majors as a fulfillment of laboratory science degree requirements. These courses do not have mathematics prerequisites and use minimal amount of mathematics. Is it worthwhile adding more mathematics in conceptual physics courses? How would it affect students' science attitudes and anxieties? I have devised and incorporated mathematical activities (formula appreciation activities) in a Conceptual Physics course offered at Queensborough Community College. Most of the activities were comprised of a) making sense of formulas by examining limiting cases, and b) identifying proportionalities between variables in the formulas. I have evaluated the implications of the implementation on students' science attitudes and anxieties in a quasi-experimental control-group design study. In this poster I will present examples of such activities and discuss the implications of the implementation.

PST2G29: 1-1:45 p.m. Experiences of Assessment in the Sciences Laboratory, in the UPSLP

Poster – Carlos A. Arriaga Santos, Universidad Politécnica de San Luis Potosí, Urbano Villalón 500, San Luis Potosí, SLP 78363 México; CARLOS.ARRIAGA@UPSLP.EDU.MX

José Guevara Álvarez, Universidad Politécnica de San Luis Potosí

César E. Mora Ley, Mario H. Ramírez Díaz, Daniel Sánchez Guzmán, CICATA-IPN

The Polytechnic University of San Luis Potosí (UPSLP) has promoted the application of a new model of education, based on the development of professional competencies that the students should possess after graduating. This model has required rethinking the methodology, both in the classroom and in the laboratory. Assessment is the main aspect of this new focus, and allows verification of the grade of development of certain aspects such as knowledge, skills and attitudes that the student has reached in a given period of time. This work presents some reflections derived from the experience in the implementation of the evaluation under the focus of the Education Approach in Competencies, as well as the evolution of the practice in the science laboratory.

PST2G30: 1:45-2:30 p.m. Comparative Educational Outcomes from Three Introductory Physics Courses

Poster – Jack R. Olsen, University of Colorado, Physics Education Research Group, Boulder, CO 80301; flabnatz@gmail.com

Michael Dubson, Noah D. Finkelstein, Katherine A. Goodman, Edmond Johnsen, David H. Lieberman, University of Colorado-Physics Education Research Group

While popularized for their potential of low-cost and broad access, Massively Open Online Courses (MOOCs) are not fully understood nor well researched in terms of educational impacts. This study examines some of the educational outcomes from a MOOC that was designed to parallel a traditional brick-and-mortar lecture of 900 students. While the MOOC initially enrolled an audience of nearly 16,000 students, a mere 1.5% actually completed the MOOC. Four times as many students completed the brick-and-mortar course. Complementing the MOOC and traditional offerings of Physics 1, we also examine a special physics course held as part of a live-in residential community. In contrast to the MOOCs, these residential courses are characterized as high-touch and locally based. Student demographics, performance, and retention were compared for the three approaches to teaching the same physics content.

Session PERC: PERC Bridging Session

Location: Northrop Auditorium
Sponsor: AAPT PER
Date: Wednesday, July 30
Time: 3– 4:30 p.m.

Presider: Tim Stelzer

PERC01: 3-4:30 p.m. Technology and Instructional Reform: Beyond the Classroom

Invited – James Fairweather, Michigan State University, East Lansing, MI 48824-1046; fairwea4@msu.edu

Research in postsecondary education has focused on the pedagogical effectiveness of technology in the classroom. Most relevant literature focuses on students' cognitive development, professional development of faculty members, and course and curricular translation into digital platforms. The AAU Initiative for the Reform of Undergraduate Education shows that many of the factors affecting the successful use of technology in STEM education lie beyond individual faculty members and students. Reward structures that influence faculty time allocation are set at the institutional level. Administrators select educational software to control costs rather than to maximize learning. This presentation draws on recent experience with the AAU Initiative to describe the variety of factors potentially affecting faculty and student use of technology in teaching and learning.[1,2]

1. National Research Council (2012). Discipline-based educational research: Understanding and improving learning in undergraduate science and engineering. Washington, DC: National Academy Press.

2. For example, K. Kereluik, P. Mishra, C. Fahnoe, & L. Terry, "What knowledge is worth most: Teacher knowledge for 21st century learning," *Journal of Digital Learning* **29**(4), 127-140 (2013).

PERC02: 3-4:30 p.m. Apples and Oranges: Comparing a MOOC with a Standard Class

Invited – Michael Dubson, University of Colorado, Boulder UCB 390, Boulder, CO 80309-0390; michael.dubson@colorado.edu

Noah Finkelstein, Edmond Johnsen, University Colorado Boulder

David Liebermanm Queensborough Community College, New York

In the fall of 2013, we taught Physics 1 (Calc-based Mechanics) to 800 tuition-paying freshmen at the University of Colorado at Boulder. Almost simultaneously, we taught a MOOC version of the course, through Coursera, to an initial audience of 15,000 students from around the world. We made the two versions of the course as similar as possible. The MOOC students saw the same lectures, with the same Concept Tests, received the same homework assignments, and took the same exams with same time constraints, as the students in the brick-and-mortar course. The physics background knowledge FMCE pre-test scores of the two groups were remarkably similar, but less than 2% of those enrolled in the MOOC had the grit to complete the course. Those gritty 2% performed almost as well as our CU freshmen students with matching pre-test scores.

Index of Participants

Abel, Yolanda, BF08
Adams, Al J., EB03, PST2E05
Adams, Wendy K., BH03, DK03, PST2C03, PST2C38, BH
Aggarwal, Mohan D., GI01
Agra, Elise, BB03, BB04, BB05, PST1C05, PST2C24
Agrimson, Erick, DI01
Aidala, Katherine, DA02
Aiken, John M, PST2C18
Aiken, John M., ED03, FF04, FG04, GE10, GG06, PST2C35
Alfaro-Avena, Luis L., AI01, AI03
Alicea-Muñoz, Emily, AF07
Allie, Saalih, GA01, PST1C31
Amarasuriya, Deepthi, CI04
Amos, Nathaniel, ED11
Amsel, Eric, CB04
Anderson, Jon, EC
Anderson, Katheryne, PST1C33
Anderson, Ryan, DG05, PST2C37
Andrade, Albert, PST2D01
Andrew, Keith, BF02
Ansell, Katherine, BB08
Arango, Alexi C., GG02
Arndt, Markus, GH08
Arriaga Santos, Carlos A., PST2G29
Aryal, Bijaya, FD09, GC10, W42, PST1D04, PST2C42, FD08
Astolfi, Cecilia, EF03, PST1C14, PST2F04
Aubrecht, Gordon J, PST1D16, CD05, PST1D08, PST1D17
Ayars, Eric, GC12
Ba, Harouna, GI02, PST2G15
Bacon, Pam, DA05
Badeau, Ryan C., DG01, DG02
Baier, Gary, EJ
Baily, Charles, EF03, PST1C14, PST2F04, W30, W40
Baird, Dean, W19, TOP01
Bajracharya, Rabindra R., GA05, PST1C08, PST1C09
Baker, Blane, GG03
Baker, David, BC03
Balan, Aurelian, BI02
Ballesteros-Roman, Alejandro, GA12
Bapat, Madhuri, BK02, PST2A01
Baranowski, Rebecca, GD01
Barger, Marilyn, PST1B18
Barker, Brent W., GE01
Barr, Alex M., GE02
Barron, Jose V., AI01, PST1B03
Barthelemy, Ramon, DA04
Bartley, Jessica E., BE07, FK, FJ
Batalden, Spencer, CI09
Bates, Simon P, GI09
Baumann, Mark, GE02
Baylor, Martha E, PST2G19
Beauchamp, Kara, EJ05
Becchetti, Frederick D., CI08
Beehler, Adam, W29
Beeker, Daniel E., GG05
Behringer, Ernie, CC
Beichner, Robert, DJ01, DJ04
Belcher, John, CE03, BA01
Belloni, Mario, EI02, FA03
Benson, Jeremy, BF
Benson, Mishal, AA04
Berenson, Rhoda, GC08
Berlinghieri, Joel C., PST2D05
Beroz, Farzan, PST1B01, PST1B07
Berrera, Regina, W09
Berquó, Thelma S., PST2B09
Bertram, Charles, CB03, GA07, PST1C07
Bertram, Charles J., PST1C06
Bettis, Cliff, PST1A01
Beverly, Nancy, PST1D03, W20, AD, EB
Blackman, Matthew A., CJ03
Blanco, Carlos, SPS12
Blasing, David B., PST2B21
Bobrowsky, Matthew, FD02, PST1E04
Bogdan, Abigail M., ED01
Boggs, Andrew, BB09
Bohacek, Peter, EI01, W02, AA
Bollen, Laurens, CI03
Bonham, Scott, EH05, PST1B04
Bonn, D A, PST1B17, DE08
Bortner, Larry J., PST1B06
Boudreaux, Andrew, AF03, CB02, W31, BB
Boyd, Sylke, PST2G06
Boyles, Jason, BF02
Brahmia, Suzanne, DD03, W46, W31
Branch, John, GG04
Branchaw, Janet, FH02
Bravo, Silvia, GG09
Brazzle, Bob, FE04
Breckner, Ross, CI09
Breslow, Lori, BA01
Brewe, Eric, BE07, BH01, FC04, FK01
Brewer, Mary M., GF05
Brookes, David, FC04, GF03, FF02, FF03, W11
Brown, Benjamin R., DC05, PST2C04
Brunschwig, Fernand, FI01, PST1E07
Burciaga, Juan, FB01, BD, DA, EF
Burkett, Mitchell, BB03
Butler, Carola, AI04
Butler, Malcolm B., PST1E06
Caballero, Danny, FA
Caballero, Marcos, PST1C12, PST2C08, PST1C26, PST1E11, PST2B16, W30
Cady, Barbara B., GI01
Callan, Kristine E., FD05
Cao, Mengdi, SPS08
Caraher, John M., DH03
Cardenas, Meinhard B, CI05
Cardnell, Elisa, CJ01
Carducci, candace, PST2G13
Caretta, Raul, PST1B18
Carlsmith, Duncan L., GC03
Carter, Ashley, FE02
Carter, Tom, DI
Carver, Jeffrey S., FC03, PST2B12
Castaneda-Emenaker, Imelda, PST1E02
Castillo, Adam, CI05
Cecire, Kenneth W., W26, CD
Chabay, Ruth, FA01
Champaign, John, BA03, EJ02
Chandrasekhar, Meera, AA08
Chasteen, Stephanie, FC06, PST1C36, GC07
Chavez-Pierce, Juan E., AI01, PST1B03
Chen, Min, BC06
Chen, Ying, PST1C26
Chen, Zhongzhou, BB06, W43
Cherney, Michael G., EB02
Chi, Cheng, SPS09
Chini, Jacquelyn J., GE08, GE09, PST1E06
Chinowsky, Paul, GB08
Choi, Gowoon, PST2B03
Christensen, Tom M., PST1B18
Christensen, Warren M., AE01
Christian, Wolfgang, EI02, FA03, CA
Churukian, Alice D., DJ05, EB08
Chávez Lima, Eduardo, PST2G05
Cid, Ximena C., FJ02
Cise, John P., BJ05
Clark, Jessica W., BE06, PST1C22
Close, Hunter G, ED05, ED06
Close, Eleanor W., ED05, ED06
Coble, Kim, W36, AG
Coleman, Derrek, CG02
Colvin, Kimberly, EJ02, BA03
Concannon, Kristi D., PST2C19
Conn, Jessica, ED05, ED06
Cook, Jerry, BB09
Corbo, Joel C., GB08
Countryman, Colleen L., GC01
Cox, Anne J., DK04
Crady, Peter, PST1B19
Craig, Matthew W., PST2G24
Creamer, Jessica G., PST1D16, PST1D17
Crist, Randall, PST2B13
Cronin-Hennessy, Daniel, CD01
Crouse, Kristin, GC09, PST2C14, PST2C15, GC10
Crowe, Daniel M., PST1B21, BG
Crumley, Jim, DA05, PST1B16
Cruz, Laura, PST2G27
Cui, Xintu, BC06
Cummings, Karen, GB04
Cunningham, Mark, BF05
Czujiko, Roman, T01
Dahlberg, E. Dan, FE01
Dancy, Melissa, DJ01, DJ04, GB08
Dannon, Vic, GB07
Dare, Emily A., PST1C37
David, Pritchard, BB06
De Cock, Mieke, CI03
De La Torre, Luis, CA04
DeMuth, David M., CD04
DeVore, Seth T., DC07, PST2C28, PST2C29, PST2C30
Deardorff, Duane L., DE07, DJ05, EB08
December, Alyssa, PST2G15
Deetz, Stanley, GB08
Demaree, Dedra N., PST1D01
Deng, Ziling, SPS16
Denicolo, Glenda, PST1B23
Desbien, Dwain M, PST1E03, GD01
Devine, Kathryn E., PST2B20
Di Rienzi, Joseph, FK04
Dietz, Richard D., PST2C03
Ding, Lin, AH01, PST1C24
Dinkelmeyer, Kelley, PST2G27
Dison, Holly, GD01
Do, Huong-Tra, FD04
Docktor, Jennifer, BB02, AF04, PST1C09, PST1E15, PST1E16
Doluweera, D. G. Sumith P., AI04
Donforth, Luke, TOP02
Donaldson, Nancy, W20
Donnelly, David, ED05, ED06
Dori, Yehudit Judy, CB01
Dormido, Sebastian, CA04
Dorsey, Chad, GI08
Dostal, Jack A., CJ02
Dou, Remy, GG08
Doucette, Daniel, PST2D07
Doughty, Leanne, AF02, PST1C12, PST2C08
Douglas, Scott S, FF04, PST2C18, ED03, FG04, GE10, GG06, PST2C35
Dounas-Frazer, Dimitri R., FH03, CG
Dourmashkin, Peter, BA01
Dowd, Jason E., PST2C20
Dragoiu Luca, Tiberiu, GH01, PST2G12
Draxten, Brian H., CF02
Dreyfus, Benjamin, FF06, PST1C32, FF05, GA10, GA11, PST1C25, PST2B18
DuBose, Rachel, DI01
Dubey, Archana, GE09
Dubson, Michael, BA02, PERC02, PST2G30
Duda, Gintaras, PST2B13, GE03, PST2C39
Duffy, Andrew G., FK02, W23
Dugan, James M., GB05
Dull, James D., PST2G07
Duman, Timothy A., BC02
Dumitriu, Ileana, PST2G13
Dunbar, Robert L, PST1D04, PST2C42
Dunlap, Justin, EB06, BF06
Dyer, Joshua M., EB05
Ebini, Raiya, DC08
Eblen Zayas, Melissa A., PST2A05
Edwards, Vernessa M., GI01, PST2G10
Eldar, Osnat, ED09
Ellia, Joshua A, PST1C37
Emenike, Mary, DG04
Emigh, Paul J., BE03
Engelhardt, Larry, GC11
Engelhardt, Susan M., BF04
Engelhardt, Paula V., FC02, PST2C44, W37
Engelman, Jonathan A., PST2C17
Esquembre, Francisco, CA03
Esswein, Jennifer L., PST1D16, PST1D17
Estrada-Cabral, Jesus, AI03
Etkina, Eugenia, AF01, BB07, BG06, PST1C11, PST2C22, PST2C41, PST2E01, W11, W46
Evans, Matt, BD03, GF

Evans, William R., GA04
Fairweather, James, PERC01
Fakcharoenphol, Witat, DG09
Falk, Michael, BF08
Febbraro, Michael, CI08
Feldman, Gerald, GE06
Feng, Ziying, SPS14
Ferdenzi, Anita, BH04
Finkelstein, Noah, BE04, GB08, PERC02, PST1B12, PST1C21, BA02, PST2G30
Finn, Rose, ED12
Fischer, Susan, GF08
Fisher, Brian, GG07, PST2C12
Flarend, Alice, W24
Flarend, Richard E., CF03
Flaten, James, BJ03, DI01, PST1D07
Flood, Jane D., PST2B04
Flores Garcia, Sergio, AI01, PST1E12
Flournoy, Alex, FD05
Foote, Katie, DJ01, DJ04
Forrest, Rebecca, CK03
Foster, Thomas M., W34
Fouch, Kayla, GE01
Fracchiolla, Claudia, BB05, ED08, PST1E13, PST2C24
Frank, Nathan H., EB04
Franklin, Donald G., EB07, PST1B08
Fredericks, Colin, BA03, PST2E03
Freedman, Ian, BI03
French, Debbie A., PST1E02, AF06
French, Richard M., PST1E02
Frick, Seth, PST1D07
Frisch, Kayt E., PST2B08
Froberg, James, PST1B02
Frodermann, Evan, FD08, BB01, BB02, GC09, GC10, PST2C13, PST2C14, PST2C15, W20, W42
Gaffney, Jon D. H., FD07, W44
Galli, J. Ronald, GF10
Gallis, Mike, GI
Galloway, Ross K, AC03, ED10
Gao, Yue, SPS01
García-Clemente, Felix J, CA03
Gauthier, Alexandre, PST2C28
Gealy, Mark W., PST2B09
Gelderman, Richard, BF02, PST2A03
Geller, Benjamin, FF06, PST2G01, PST2B18, FF05, PST1C32
Gentile, Michael, PST2E01
Gervais, Thomas, BB10
Getaneh, Misganaw, SPS11
Giannini, John, EB01, PST1C35
Gibbons, Thomas C., PST2A09
Gidzak, Bonnie, AB03, AB
Gilbert, Dennis, GF04, PST2B06
Gilbert, Richard, PST1B18
Girwidz, Raimund, CA05
Gitomer, Drew, AF01
Gjertsen, Peg, FA02
Gladding, Gary, DG06, DG07, DG08
Goering, Kevin Calvin, PST2B15
Goertzen, Renee Michelle, DB01, FH
Goldberg, Bennett B, FK02
Goldtrap, Michael, EF01
Gomez, Enrique A, PST2G27
Gong, Yu, PST1D06
Gonzalez, Jaun L., PST1E12
Gonzalez, Maria D., AI03, PST1B03
Gonzalez, Barbara L., BG02
Goodman, Katherine, BA02, PST2G30
Gosch, Christopher, PST1D07
Gouvea, Julia, PST2B18
Gouvea, Julia S, PST1C32, FF05
Grafe, Alan G., CI10
Greco, Edwin F, FF04, PST2C18, ED03, FG04, GG06, PST2C35
Gredig, Thomas, GI06
Green, Adam, PST1D13
Greenslade, Thomas B., AI05
Gregorcic, Bor, BG06, PST2C22,
Grimes, Paul, AF02
Grosz, Nathaniel C., GE05
Guegan, Philippe J, BG04
Guevara Álvarez, José, PST2G29
Guillemette, Jonathan, GH04
Guisasola, Jenaro, PST1C15
Gupta, Ayush, DI03, GA10, GA11, PST1C25
Gupta, Jay, FH01
Gutmann, Brianne, DG08, DG07
Haag, Brooke, BI08
Hafele, Anna, DG05, PST2C37
Hancock, Sally, ED10
Hanstorp, Dag, AI06
Hardage, Sara, BF05
Hardy, Judy, ED10
Hare, Emily, BK03
Harper, Danielle, SPS12
Harper, Kathleen A, W34, ED04, PST2C34, AH
Harrell, James W., AF05
Hartman, Mark, PST1D09, PST2B10
Hassel, George, ED12
Haugen, Andrew, DI02, DI04, PST1B14
Hazari, Zahra, FF08, FK03
Hazelrigg, Conner, GG03
He, Yang, SPS14
Hechter, Richard P., EE08
Heckler, Andrew, ED11, FH01, PST2G25, DG01, DG02, GA03, ED01, GA02
Heering, Peter, DF02
Heller, Ken, FD08, BB01, BB02, GC09, GC10, PST2C14, PST2C15, PST2C13, W42
Henderson, Charles, CE01, DJ01, DJ04, FG03, GB03, PST1C10
Hendrickson, Erik, BD03
Henning, Steve, W15
Henry, Christopher, PST2G21
Henry, David R., GB01
Heradio, Ruben, CA04
Hilborn, Robert, AD02
Hill, Bradford, W27, GD06, PST2B10
Hinko, Kathleen A., BG03
Hinrichs, Brant E., BE09, PST2C21
Hirsch, Andrew, PST2B21, PST2D04, PST2G14
Hlousek, Zvonimir T, GI06
Hobbs, Robert, AC02
Hodapp, Theodore, EG01, EG
Hoellwarth, Chance, EC01
Holbrow, Charles H., CE02
Holden, Elizabeth, DA03
Holmes, Natasha G., DE08, PST1B17
Holt, Kathy, BF01
Hooper, Eric J., FH02
Hopf, Martin, GH08
Hou, Jixuan, PST1D05, SPS03, SPS06
Hovan, Scot A., FF01
Howes, Ruth H., EH06, EH
Hsu, L., FD08
Hsu, Leon, BB01, BB02, GC10, PST2C14, PST2C15, W42
Hsu, Leonardo, GC09, PST2C13
Hu, Chunxuan, SPS07
Hu, Dehui, BE04, PST1C21
Huang, Brian C., W16
Huard, Zachary, PST1B06
Huber, Thomas M., CI09, PST1B19, PST1E02
Huggins, Elisha, GG10
Hunt, Benjamin, PST2G22
Hunt, Doug, PST1E02
Hutson, John, PST1C05
Hyland, Peter, BC03
Irving, Paul W, PST2B16, AE03, PST1C26, PST1C28
Isaksson, Oscar, AI06
Ishimoto, Michi, PST2C01, PST2G26
Ita, Meagan, ED04
Ives, Joss, DG10, GI09, PST2C40
Iyer, Deepak, DG04
Jackson, David, GC05, GC06
Jackson, Steven, PST1B01
Jackson, Koblar A., BB01
Jackson, David P., GC04
Jackson, Steven R., PST1B07
Jacobs, Mark W., GH06
Jaeger, Herbert, FE05, PST1B15
Jalkio, Jeff, PST1D13
Janssen, Michel, AB01
Jhun, Youngseok, GB02, PST2B19
Ji, Jing, SPS03, SPS06
Jiang, Chen, SPS14
Jin, Jieying, PST2G06
Jing, JI, PST1D05
Johnsen, Edmond, BA02, PERC02, PST2G30
Johnson, Andy P, DG05, PST2C37
Johnson, Jordan, SPS11
Johnson, Keith, PST2A02
Johnson, Olivia, ED10
Johnson, Sarah Durston, BF03
Johnson, Jolene L., DA06
Johnston, Adam, CB04
Johnston, Marty, PST1D13
Jones, Brian, W22, TOP03
Jones, Darrick C., BB07, PST1C11
Jones, Dyan, CI06
Jones, Kolton, PST1B04
Jones, Tyler, DG03
Jordan, Connor, PST2C38
Jung, Hana, GB02
KK, Mashood, PST2G04
Kadel, Kamal, FF02
Kagan, Mikhail, BC07
Kanim, Stephen, W31
Kang, Hyunjung, PST1C38
Karam, Ricardo, PST1E05
Kardelis, David, EE
Karkheck, John, GI03
Karlsteen, Magnus, AI06
Kaster, Stephen, PST1B16
Kay, Laura, DA01
Kecskemety, Krista M., ED04
Keeports, David, EJ04
Kelley, Patrick A., SPS12
Khatri, Raina M., GB03
Kiepura, Laura, PST2C23
Killion, Patrick, PST2G01
Kim, Siyoung, PST2B19, PST2A10
Kinner, Freya, PST2G27
Kiskis, Joseph, BD02
Kiss, Monika, BF09
Klassen, Mary Ann Hickman, W13
Klassen, David R., DH02, DE
Klingler, Noel, GE06
Kluender, Edward, PST1B19
Knoles, Jacob, GC12
Koenig, Kathy, GC04, PST1B06, PST2C17, GC05, W08
Koh, Daegene, AF07
Kohl, Patrick B., CI01, FC01, PST2F06
Kohnle, Antje, W40, DC04
Korsunsky, Boris, W43
Kortemeyer, Gerd, EG04
Koss, Emily R., PST2G22
Kosztin, Dorina, AA08
Koupil, Jan, PST2E07
Kozminski, Joseph F., DE04
Kramer, Laird, DB02, FC04
Krebs, Eric J., EF04
Krieger, Darilyn, CJ01
Kryjevskaia, Mila, GA06, GA08, GE05. CB
Kuo, Vince, FD05, DJ, FC
Kustusch, Mary Bridget, GF08, AE
Kutschera, Ellynne, EB06
Kwon, Chuhee, GI06
Laffey, Evelyn H., DE06
Laird, Angela R., BE07
Lampert, Lester, BF06
Lange, Cassandra, CB03, PST1C07, PST2C16
Lanz, Colleen, GC02, PST2G17
Lark, Adam C., DE05
Larson, Adam M., BB04
Lasry, Nathaniel, GH04
Lathrop, Renee, GD
Lauterburg, Urs, EE01
Laverty, James T, PST2B16, FD03, PST1E11
Laws, Priscilla, GC05, GC04, GC06, W08, W15, W32, CK
Lazaroff-Puck, Cameron, AB02
Le, Thanh K., GA08
Leal, Hector, BF05
Lee, Kyungmi, PST1C27
Lee, Kevin M., W28, PST1A01, TOP08
Leif, Todd, BI
Leniz, Ane, PST1C15
Levy, Jeremy, PST2C28
Lewandowski, Heather, CG03, PST1B12, BE04, PST1C21
Lewis, John P., BK01
Li, Jing, PST1C17, PST2C27
Li, Longfei, SPS16
Li, Yaran, SPS01
Li, Sissi L, BG02, FK05, PST1C29
Liao, Zi, SPS08
Lichter, Joseph, FC04
Lichty, Lyle R., EE06
Lieberman, David, BA02, PERC02, GE11
Lietz, Martha, AA02, W10
Lin, Shih-Yin, ED03, FF04, FG04, GE10, GG06, PST1C04, PST2C18,

PST2C35
Lincoln, James J., EE04, PST1E01
Lindaas, Steve, W29
Lindell, Rebecca, PST2B21., PST2C02
Lindsey, Beth A., GA09
Lindstrom, Christine, BH05
Liu, Alwina, BA03
Liu, Chufeng, SPS13
Liu, Zengqiang, DE10, W03
LoPresto, Michael C., CG05, PST1B10, PST1B20, PST1B22
Lock, Robynne M., FK03
Loera, Eduardo J., PST1E12
Løken, Sigurd, BH05
Lopez del Puerto, Marie, FD06, PST1D13
Loschky, Lester C., BB03, BB04, PST1C05
Losert, Wolfgang, EB01, PST1C35, PST2G01
Losert Valiente-Kroon, Christiane M., GH08
Loverude, Michael, AH03, BG02, PST1C29, FK05
Lowe, Mary L., PST2G11
Lowry, Matt, W19
Ludwig, Randi, GE02
Luna-Gonzalez, Juan, AI03
Lunk, Brandon, W44, DJ03
Luther, Bryan A., PST2B09
Luzader, Stephen, W45
Lv, Yiru, SPS07
Madsen, Adrian, DD01, PST2C10, W38
Madsen, James, GG09, FD
Magana, Cordero, SPS12
Magana, Aljandra J, PST1D06
Maier, Steven, , TOP04
Maiullo, David P., PST2D03
Majors, Twanelle W., PST2C44
Mallmann, A. James, GF07
Maloney, David, PST1C23, W34
Malysheva, Marina, PST2E01
Mann, Elizabeth K., PST2G18
Manning, Heidi L., PST2B09
Manogue, Corinne, EF01
Manzoni, Luiz A., PST2B09
Maries, Alex, PST1C10
Maries, Alexandru, ED07, FG03, PST1C01, PST1C02, PST1C03, PST1C04, PST1E18, PST1E19, PST2F07
Marshall, Eric, DG03
Marshall, Jill A., CI05
Marshman, Emily, FG03, GE04
Marshman, Emily M., DC06, PST1C10, PST1C18, PST1C19, PST1C20, PST2C05, PST2C31, PST2C32
Martell, Eric C., PST2G08, PST2G09
Martin, Samuel, GE10
Marx, Jeffrey D., GB04
Mason, Andrew, BB01, CB03, GA07, PST1C06, PST2C13, PST2C16, CH
Mason, Andrew J., AA04, PST1C07
Masterman, Julia R., PST2G22
Mateycik, Frances, FB, GC
Mathelitsch, Leopold, CA02
Mathieu, Robert, FH02
Mazur, Eric, GH04
McCall, Richard P., PST1D15
McCann, Lowell, CI07
McCarthy, Leilah, BI04
McColgan, Michele, ED12, PST2D01, PST2E02
McCombs, Michelle, FH01
McCoy, Jonathan, FE03
McCoy, Bradley K., PST2B07
McCullough, Laura, AH02
McDonald, Scott, AF02
McDonald, Spencer, DI01, PST1D07
McIntosh, Gordon C., PST1B02
McKagan, Sarah, BC05, BC04, DD01, PST2C10, W38
McMillan, David J, CF01
McNeil, Laurie, DB04, EB08
McPadden, Daryl, FK01
Mecca, Stephen, BC01
Mechtenberg, Abigail, W09
Medsker, Larry, GE06
Megowan- Romanowicz, M Colleen, GD07, FI
Mehta, Jignesh, PST2D04
Mehta, Pankaj, FK02
Mellema, Steven, BJ03
Meltzer, David E., DD04
Menard, David, BB10
Menke, Carrie A., DD06, PST1D10
Meredith, Dawn C, PST1C13
Merrell, Duane B., EE02
Metz, Donald, DF02
Michelini, Marisa, BG07, FG01, PST1E09
Michonova-Alexova, Ekaterina, PST2G20, PST2G21
Miedjensky, Shirley, ED09
Mikula, Brendon D., GA03
Miller, Casey, AG01
Miller, Kate E., FI02, PST1D09
Miller, Paul M., FC03, PST2B12
Mittapalli, Kavita, BF08
Montez, Rodolfo, AG02
Moore, Heather, PST2B10, W27
Moore, Nathan, DI02
Moore, Kimberly A., EB01, PST1C35, W20
Moore, Heather J., PST1D09, GD03
Moore, Nathan T., DI04, PST1B14
Moosvi, Firas, GI09
Mora Ley, César E., PST2G29
Morin, Maxim, BB10
Morin, Brooke C., ED04
Morrison, Andrew, BI07
Morse, Robert A., AA01
Moss, joshua, PST2G13
Mountcastle, Donald B, BE06, PST1C22
Moustakas, John, ED12
Mungan, Carl E., PST2F03
Murphy, Scott, PST2B10
Murphy, Sytil, EH01
Murphy, Scott J., GD04
Muthyala, Rajeev S., PST2C42
Mylott, Elliot, EB06, BF06
Nadji, Taoufik, EJ03
Nagel, Megan L., GA09
Nainabasti, Binod, FF02, FF03, GF03
Nairn, Kris, DA05
Nanes, Roger, BG02
Nelson, Jane, AF05
Nelson, Jim, AF05
Nelson, Tobias, PST2F02, SPS02
Nesbitt, Lori, DK01
Neumeyer, Xaver, DJ01, DJ04
Nguyen, Dong-Hai, FD04
Nguyen, Thanh-Nga, FD04
Niederriter, Charles, BJ03
Nissen, Jayson M., FF09
Niyogi, Devdutta, PST2G14
Nord, Paul M., EE05
Norris, Peggy, CD04
Norvelle, Nora, EH01
Novobilsky, Shauna, CI06
O'Kuma, Thomas, FB03, PST1E03
Ohmann, Paul, PST1D13
Olesya, Olesya I, AI04
Olf, Ryan, CG02
Olsen, Jack R., PST2G30
Otero, Valerie K, BG04
Paesler, Michael A., GC01, PST2G17, GC02
Palatchi, Caryn A., PST1D16, PST1D17
Palczewski, Ari, PST1B16
Palmquist, Bruce, AI02
Park, Seo Bin, PST2D02
Parker, Ian, PST1D18
Partensky, Michael B., GI05
Pasqualin, Jordan, GD05, PST2B10, W27
Passante, Gina, BE03
Patel, Deena, W09
Patt, Colette E., AG03
Paulson, Scott, FC05
Pawl, Andrew E., FD01, PST2B14, PST2E06
Pawlak, Alanna, PST1C12
Pawloski, Gregory, GI07
Pearson, Christopher, DJ02
Pelz, Jonathan, FH01
Perkins, Katherine K, FC06, PST1C36, GC07
Petricka, Jessie A., PST1D14
Pfund, Christine, FH02
Phillips, Jeffrey A., GF02, PST2C33
Pierce, Zoe, GE06
Planinsic, Gorazd, BB07, BG06, PST1C11, PST2C22,
Plisch, Monica, DB01, DB
Pollard, Benjamin, PST1B12
Pollock, Steven, EF03, PST1C14, PST2F04, PST2F05, W30, DD02, PST2C08, BE01, EF02
Pond, Jarrad W.T., GE08, GE09
Ponnambalam, Michael, W18, BK05
Porter, Chris, FH01
Porter, Christopher D, PST2G25
Potvin, Geoff, FF08
Prather, Edward, FG02
Price, Edward, DH01
Price, Kent J., AA05
Pritchard, David, EJ02, W43, BA03, CE03
Proleiko, Igor V., AA06
Purcell, Kenneth M, PST2G16
Purohit, Vatsal, SPS12
Putman, Gregory W., PST2G18
Pyper, Brian, AF
Quan, Gina M., DI03
Quarderer, Nathan A., BI06
Quedado, Kimberly, FC03, PST2B12
Rahman, Talat S., GE09, PST1E06
Raine, Derek, DC03, W40
Ramirez Diaz, Mario Humberto, PST1D11, PST2G05, PST2G29
Ramsey, Susan, TOP11
Raschke, Lynne M., PST1C33
Ray, Gene, PST1E08
Ray, Kimberly L., BE07
Rayyan, Saif, BA01, CE03, BA
Razavi, Shahab, FF07
Rebello, N. Sanjay, BB03, BB04, ED08, FD04, PST1E13, BB05, PST1C05, PST2C24
Redish, Edward F., GA10, GA11, PST1C25
Redman, Jerry, AF04, PST1E15
Reeves, Shawn, EH02, W01, W14
Regan, Thomas J., AA03
Reichlmayr, Thomas J., GC06
Reiner, Megan, DI02
Reitz, William E., DK02, DK
Restivo, Evelyn D., CD03
Reynolds, Julie A, PST2C20
Rhees, David J., DF01, W01, W14
Richards, AJ, BB07, PST1C11
Richards, Shelby, PST2G06
Richardson, Arlisa L., PST2B17
Riedel, Michael C., BE07
Rieger, Georg, GI09
Riendeau, Diane M., BJ02, BJ, CJ
Riggins, Jay, CI08
Robinson, Alma, EC02
Robinson, Steve, FC02, W37
Rodriguez-Costacamps, Laura, GI02, PST2G15
Roehrig, Gillian H, PST1C37
Rosenblatt, Rebecca J., PST2C07
Rosengrant, David, PST1E08
Rostedt, Mats, AI06
Rouinfar, Amy, BB04
Roundy, David, EF04
Rourke, Devin, BJ01
Rowe, John M., EC05
Roy, Anindya, BF08
Roychoudhury, Anita, PST2D04, PST2G14
Ruiz, Oscar, AI03, PST1E12
Rundquist, Andy, DH04, GG
Rusert, Maria, AI04
Rushton, Greg, PST1E08
Ryan, Q., FD08
Ryan, Qing, BB02, GC09, PST1C14, PST2C14, PST2C13, EF03, PST2F04, W42
Sánchez Guzmán, Daniel, PST2G29, GA12
Sabella, Mel, AD01, BH02
Sabin, Roberta, PST2G11
Sadaghiani, Homeyra R., BE02
Sadler, Philip, FF08
Sage, Starr K., PST2C42
Salata, Mark, AA08
Salazar, Maria C., PST1B03, PST1E12
Salgado, Roberto, PST2F02, SPS02
Salisbury, Don, BC03
Sampere, Sam, W12, W33, AI
Sams, William, GC02, GC01, PST2G17
Samuels, Jason, GG07, PST2C12
Sanchez, Jose, CA04
Sander, Leonard M., EA03
Santi, Lorenzo G, FG01
Sapia, Peppino, CA01
Sauncy, Toni, T01, SPS
Sawtelle, Vashti, FF05, FF06, PST1C32, PST2B18
Sawtelle, Vashti A., FF10, PST1C30

Sayre, Eleanor, PST1C26, PST2C10, AE03, DD01, PST1C28, W38, DD
Scaife, Thomas M., GA02
Scanavino, Michelle, BI05
Schaffer, Kathryn, CG04, PST2A08
Schamschula, Marius, AF05, GI01
Schatz, Michael F, AF07, FF04, PST2C18, ED03, EG02, FG04, GE10, GG06, PST2C35
Scheller, Kent W., PST1D18
Scherr, Rachel E., DB01
Schmitt, Bill, PST1D16, PST1D17
Schroeder, Noah, DG06, DG07, DG08
Schroeder, Daniel V., W23
Schulte, Jeff B., EF04
Schultz, Scott F., BI01
Schumacher, Jacob P, PST2G20
Schunicht, Shannon A., GG01
Schunn, Chris, PST1E17
Scott, Alan J., GD02
Scott, Tyler, FF08
Sealfon, Carolyn D., DE06
Sederberg, David, PST2C25
Selen, Mats, BB08, EG03, PST2G09
Semak, Matthew R., PST2C03
Sengul, Ozden, GE07, PST2C23
Seo, Hye Young, PST2B02
Seo, YoungSeon, PST2B01, PST2A11
Shaffer, Peter S., BE03
Shah, Mili, PST2G11
Sharma, Manjula D., DC02
Shastri, Ananda, DE03
Shekoyan, Vazgen, BH04, PST2G28
Sheldon, Steven, BF08
Shen, Han, BC06
Shepardson, Daniel, PST2D04, PST2G14
Sherman, Derin A., BK04
Sherwood, Bruce, FA01, T02
Shively, Chris, GB01
Shropshire, Steve, TOP09
Sibbernsen, Kendra, W28
Sievert, Patricia, BF07, PST2G03
Simmons, James, EH04
Simpson, Caroline E., PST2C26
Singh, Aditya, GC03
Singh, Chandralekha, DC01, DC05, DC06, DC07, ED07, FG03, GE04, PST1C01, PST1C02, PST1C03, PST1C04, PST1C10, PST1C17, PST1C18, PST1C19, PST1C20, PST1E17, PST1E18, PST1E19, PST2C04, PST2C05, PST2C27, PST2C28, PST2C29, PST2C30, PST2C31, PST2C32, PST2F07, W25, W39, FG
Singh, Vijay, PST2G04
Smith, Emily, EF01
Smith, Kaye, DI01
Smith, Donald Andrew, CJ04
Smith, David P., EB08
Smith, Jr., Daniel M., W36
Sokoloff, David, CK01, W32
Solomon, James, PST1B18
Sonnert, Gerhard, FF08
Sorby, Sheryl, FJ01
Sorenson, Stephen, PST1B02
Southey, Philip B., GA01, PST1C31
Spalding, Gabe, FE
Spencer, Justin, DF03
Stafford, Olga A., PST2C36
Stassun, Keivan, AG02
Stecklein, Jason, GI04
Stefanel, Alberto, BG07, FG01
Steltzer, Tim, DG07, DG06, DG08, BB08
Stenson, Jared R., GH07
Stetzer, MacKenzie, BE05, PST1C16, AE02, GA06, GA08, GE05, TOP07
Stewart, Gay B., DB03
Stewart, John C., DB03 GF06, PST2E04
Stille, Dale, W12, W33
Stokes, Harold T, GF09
Stolpe, Lars E., PST2G22
Stottrup, Benjamin L, BC05, BC04
Straub, Miranda C P, BF10, PST2D06
Strickhouser, Nicole, PST2G14
Stroupe, David, PST2B16
Stuewer, Roger, DF
Sturm, David E., EE07, PST2A07
Su, Haoliang, SPS10
Suarez, Enrique A., BG04
Suarez, Oscar Jardey OJS, BE08, PST2C43
Subiño Sullivan, Carol, AF07
Sudhakaran, Gubbi, AF04, PST1E15, PST1E16
Suihkonen, John, PST1B02
Sunal, Dennis, AF05
Surabhi, Raj, PST2G10
Svoboda Gouvea, Julia, FF06, FF10, PST1C30
Swendsen, Robert H., EA01
Syed, Maarij, CI02
Tagg, Randall, BC08
Tan, Arjun, PST2G10
Taylor, Beverley, W45
Taylor, Zachary, GF05
Teese, Robert, GC05, GC04, GC06, W08
Teodorescu, Raluca, EJ02, W43
Terrazas-Porras, Sergio M., AI01, PST1B03
Tessmer, Stuart H, PST2B16
Thapa, Mahendra, PST1B06
Thomas, Kevin, EC03, PST1E06
Thompson, Bruce, GH03
Thompson, Kristen, EI02, EJ01
Thompson, Robert J, PST2C20
Thompson, John R, BE06, PST1C22, GA05, PST1C08, PST1C09
Thoms, Brian D, AI04
Thornton, Ronald, CK02, CK01, W32
Tidrow, Steven, BF05
Timberlake, Todd K., EH03
Tipsword, Nicole, PST2G09
Titus, Aaron, FA02, EI
Toberer, Eric S, PST2F06, CI01
Tobochnik, Jan, EA
Tomandl, Mathias, GH08
Tompkins, Reganne, FK03
Torres-Isea, Ramon, CI08
Tosa, Sachiko, GB06, PST1D12
Trampleasure, Lee, TOP05
Traxler, Adrienne L., FC04
Trees, Brad R., GF01
Treu, Becky L., BI05
Tripathi, Swapnil, GH02
Troncalli, Andra, BC03
Trout, Joseph J., PST2G02
Troy, Tia V., DI02
Turpen, Chandra, FF05, FF10, PST1C30, PST1C32, PST2B18, PST2G01, FF06
Van De Bogart, Kevin, BE05, PST1C16
van Dusen, Ben, TOP06
Van Duzor, Andrea Gay, BH02
Van Kampen, Paul, AF02, CI03, DE01
Vargas, Jamie, CG01
Vercellati, Stefano, FG01, PST1E09
Vícha, Vladimír, PST2E07
Vigil, Melissa, GB
Visnjic, Katerina, DE06, PST1B01, PST1B07
Von Korff, Joshua, GE07, PST2C23
Vondruska, Judy, DG11, PST1E14
Vonk, Matthew Ted, EE03
Vont, Matthew, W01
Wagner, Doris Jeanne, BK03, PST2C06
Walker, Elizabeth, EC06
Wallace, Marsali, ED10
Wallace, Penni H., EC04
Walvig, Steven, DF03
Wang, Jing, BB09
Wang, Kai, SPS10
Wang, Lu, SPS15
Wang, Yi, SPS08
Wangberg, Aaron, GG05, PST2C12, GH05
Wangberg, Robyn L., GH05
Ward, Kristina, PST2C39
Weatherford, Shawn A., BF09
Weber, Eric, GG07, PST2C12
Welch, John M., DE09
Wells, Connie, W10
West, Joseph O., CI02
Wheeling, Rebecca, CI06
Whitaker, Dwight L., BD01
Whitaker, Jacob T., FD07
White, Mason F., PST2G19
White, Daniel R, DG02, DG01
Wick, Kurt, W04
Wick, Susan, AC01
Widenhorn, Ralf, BF06, EB06, W20
Wiegert, Craig C., FF07, PST1B05
Wielgus, Lauren, GC03
Wilcox, Bethany R, PST2F05, BE01, DD02, W30
Williams, Celestena, FF02
Williams, Jeremiah, W35
Williams, Eric A., PST2C26
Williams, Karen A., DD05, PST1B13
Williams, Paul, W22. BK
Willis, Maxine, GC05, GC04, W15, W08
Willoughby, Shannon D., PST2A02
Winters, Victoria, GI02, PST2G15
Wirjawan, Johannes v.d., EH01
Wittmann, Michael C., BG01
Wolf, Talya, GI02, PST2G15
Wolf, Steven F., PST1C26
Wolk, Martin, DF03
Wood, Shane, CD02
Woolbright, Stephen J, PST2G20
Wozniak, Jeffrey, PST2C25
Wu, Xian, BB03, BB05, PST1C05, PST2C24
Wu, Xudong, SPS08
Wysocki, Bradley J., AA07
Yan, Jiawei, SPS13
Yang, Jie, PST2C15
Yang, Yuchen, SPS07, FF02, FF03, GF03
Yang, Yuzhao, SPS10
Yerushalmi, Edit, FG03, PST1C10
Yohn, Michael J., SPS04
Young, Daniel E., PST1C13, W20
Yu, Yeonjeong, PST2B19
Yu, Yue, SPS01
Yuksel, Tugba, PST1D06
Zajac, Richard A., PST1B09
Zavala, Genaro, FB02, DC
Zeng, Liang, BF05
Zhang, Yu, DA05
Zhang, Zhe, PST2G21
Zhang, Michael D., PST2G22
Zhang, Wendy W, EA02
Zhao, Fuli, BC06
Zhou, Qian, EJ02
Ziegler, Lynn, DA05
Zimmerman, Todd, PST2C09
Zimmerman, Charlottes M, PST2G19
Zisk, Robert C., AF01, PST2C41, W46
Zollman, Dean, EH01, DC08
Zuccarini, Giacomo, BG07, FG01
Zuza, Kristina, PST1C15
Zwart, John W., DE02
Zwickl, Benjamin M., BE04, PST1C21, AC, BC, DH
Zwolak, Justyna, EF01

Index to Advertisers

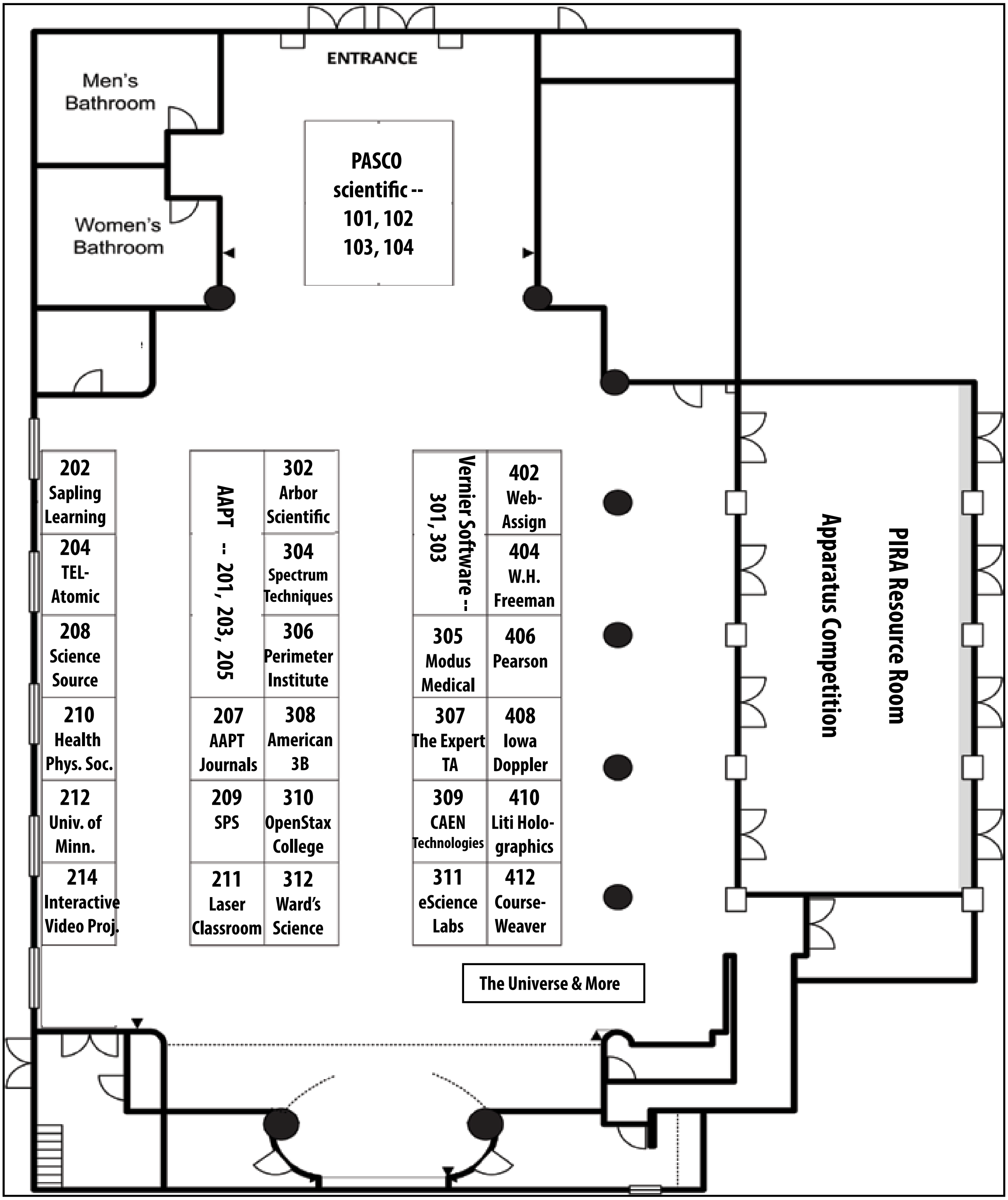
Courseweaver 15
Expert TA 19
Modus Medical . . . . Inside Back Cover
OpenStax College . . . . Inside Front Cover
PASCO scientific . . . . Back Cover
Perimeter Institute 7
WebAssign 5

Campus Map
U.M.

Exhibit Hall Map

Great Hall

Coffman Memorial Union



Coffman Union – Dining

–ChickFilA: 11 a.m. to 2:30 p.m. (M-F)

–Einstein's Bagel: 7:30 a.m. to 2:30 p.m. (M-F)

–Goldy's Game Room: (bowling alley with food options)
10 a.m. to 10 p.m. (M-F), 5 p.m. to 10:30 p.m. (Sat)

–Gopher Express: (small convenience store): 7:30 a.m. to 5 p.m. (M-F)

–Greens to Go (salads): 11 a.m. to 2:30 p.m. (M-F)

–Panda Express: 11 a.m. to 2:30 p.m. (M-F)

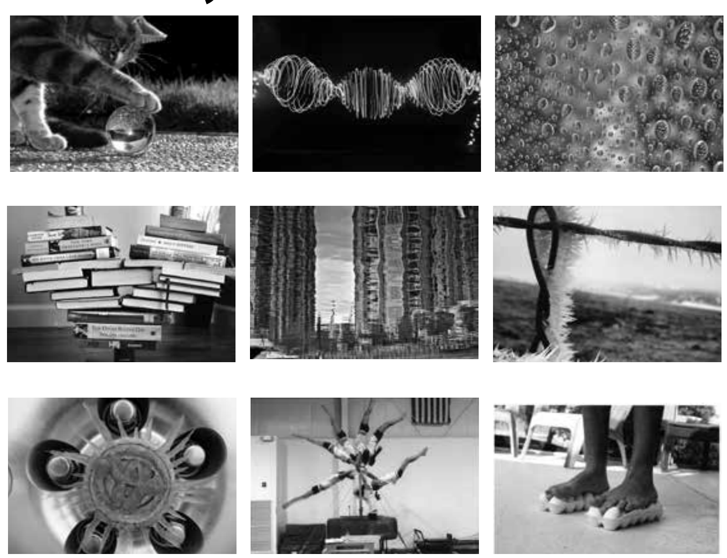
–Starbucks: 7:30 a.m. to 4 p.m. (M-F)

–Topios (pizza, calzone, etc.): 11 a.m. to 2:30 p.m. (M-F)

View Photos & Cast Votes

AAPT's 2014 High School Physics Photo Contest

The top 100 photos submitted in the AAPT's High School Physics Photo Contest will be displayed in the **Coffman Union** near the Registration area. Voting is open from Sunday night til Tuesday.



high school physics
photo contest

www.aapt.org/Programs/contests/photocontest.cfm

CALL for UNIVERSITY HOSTS
for 2017 and 2018 National Meetings

AAPT is in search of Physics Departments of Colleges and Universities interested in hosting national meeting workshops and pre-conference meetings in 2017 and 2018. This is a great opportunity to support AAPT national meeting and showcase the physics program at your university.

The following meetings are in the process of being vetted, and priority will be given to locations where Local Hosts show support.

- **2017 Summer Meeting** host sites would be in the middle of the country.
- **2018 Winter Meeting** host sites would be in the South West Coast.
- **2018 Summer Meeting** host site would be in the Mid-Atlantic and Northeast areas.

General information for Local Hosts to consider:

- National Meetings typically occur in January/February (winter) and July/August (summer).
- Average attendance: 800–1,000 (winter), 1,000–1,200 (summer).
- 30–40 Half-and Full-Day workshops occur on Saturday and Sunday.
- Smaller tandem meetings prior to and following the AAPT National Meeting ranging from 40 to 150 people are planned annually and will be supported by Local Hosts.
- A mix of campus and local hospitality community engagements will be required for a successful National Meeting.
- Local Hosts will need to submit a letter of support to AAPT prior to a site visit being planned and be a part of showcasing the area.
- A final presentation to the Meetings Committee shall take place either during a summer or winter meeting prior to a meeting being awarded.

All interested universities will be properly vetted; however, those that have the support of the hospitality community and resources (hotels, restaurants, distance to airport, activities, etc.) to fully manage the group will be considered for a site visit.

Meeting elements to be considered prior to deciding to become a Local Host:

1) ***Proximity to Airport.***
2) ***Sleeping Rooms*** – Dorm rooms (summer meetings only) and proximity to nearby hotels.
3) ***Meals*** – Mostly on own – Proximity to a variety of restaurants during workshops.
4) ***AAPT Workshops*** (Saturday and Sunday only): a minimum of 10 Lab rooms at University.
5) ***PERC*** – Physics Education Research (PER) group begins their "mini" conference for 240 participants, including 50 poster boards, plenary room and five breakout rooms.
6) ***PTRA*** – Possible Physics Teaching Resource Agents (PTRA) meeting for approximately 40 teachers one week prior to Summer Meeting. Will require additional dorm/hotel rooms.
7) ***Additional Pre-meeting Workshops*** – the possibility of an Advance Laboratory Physics Association or Two Year College Workshop would be held during a specific year. Additional information required.

To receive detailed requests for proposal, contact the Programs and Conference Department via *programs@aapt.org* or 301-209-3340.

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 $1,000 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

Hashim A. Yamani AAPT Memberships:

two-year sponsored memberships

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

Submitting an Application

The deadline for receipt of applications each year is July 1. All applications received by that date will be considered for a membership that will start on September 1 and run through August 31 two years later. A completed application will consist of:

1. The completed online application at http://www.aapt.org/Programs/grants/Yamani_instructions2.cfm.
2. A one-page narrative statement of the applicant's background and career plans, including a statement about the applicant's interest in AAPT and his or her perception of how AAPT might contribute to preparation for a teaching career.
3. The name of and contact information of one individual who can verify the applicant's qualifications.

Learn more and apply online at
http://www.aapt.org/Programs/grants/Yamani.cfm

We'll see you in San Diego, CA!

Winter Meeting '15

January 3-6, 2015

Stop by the registration desk today and get a Very Early Bird registration rate for the 2015 AAPT Winter Meeting!

We'll see you in College Park!

Summer Meeting '15

July 25-29, 2015
University of Maryland

NOTES

NOTES

NOTES