

# Forum on Education

## American Physical Society

### Fall 2016 Newsletter

*Richard Steinberg, Editor*

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## From the Chair

*Tim Selzer, University of Illinois - Urbana*

The hassle of booking airline tickets and hotel rooms for the upcoming conferences leaves me wondering if one can really justify the time and expense of attending these meetings in person, especially given the advances in video conferencing technology. However, in my own experience, there is no substitute for face-to-face meetings, and afterwards I am always happy that I chose to attend. Often it is a talk that I just happened into, or an unexpected conversation that began at a break between sessions that makes being there truly worthwhile. For amusement, I just did a quick calculation comparing the visual information available when you are physically at a presentation with viewing it online. Even with our high-definition megapixel displays, there is about 1000 times more visual information available when you are there in person. It really is a different experience.

It may seem premature to be planning for your spring conferences but April is coming early this year. In particular, the 2017 APS April meeting will be held January 28th to 31st in Washington DC. We hope that being located in the capital in January will make the meeting accessible to our regular attendees as well as encourage new participation. Chair-Elect John Stewart and his program committee have assembled an outstanding set of invited sessions ranging from teacher preparation, to online communities supporting physics education, to using 21st-century physics, to educating 21st-century students.

The Forum on Education will again sponsor a diversity reception on Sunday night. It is an excellent opportunity to socialize, enjoy some complimentary beverages and hors d'oeuvres, and recognize our new Fellows and award winners. These include this year's Excellence in Physics Education award and the award for Improving Undergraduate Physics Education. I encourage you to consider nominating your department for the award for improving undergraduate physics education, or your colleagues for the Excellence in Physics Education Award. You can find more details on the award on our website <https://www.aps.org/units/fed/awards/index.cfm>.

The 2017 March meeting is staying true to its name, and will be held in New Orleans March 13th to 17th. In addition to the Reichert Award session John and his colleagues have organized invited sessions that include Preparing for a Job in Physics, Preparing Students for 21st Century Careers, and a "New Faculty Workshop in Three Hours".

There is no denying the extra cost and effort required to attend these meetings in person, but I encourage you to make that effort. I'm sure, that like me, you will be happy you did.

Tim Stelzer

*Tim Stelzer is Chair of the Forum on Education. He is a Professor of Physics at the University of Illinois, Urbana.*

## From the Editor

*Richard Steinberg, City College of New York*

In this issue, I am happy to continue the tradition of highlighting Foundations and Frontiers of Physics Education Research conferences in the subsequent issue of this newsletter. This year, FPER: Puget Sound was held in June in Diablo Washington and was organized by Krishna Chowdary (The Evergreen State College), Andrew Boudreaux (Western Washington University), Amy Robertson (Seattle Pacific University), and Abigail Daane (Seattle Pacific University). The conference is framed beautifully by Tim Stelzer and Andrew Boudreaux in this newsletter and represented well by

articles of 3 of the plenary speakers, Michael Loverude, Cassandra Paul, and James Day.

As I continue to adjust to my role as editor, I encourage readers to reach out to me ([steinberg@ccny.cuny.edu](mailto:steinberg@ccny.cuny.edu)) with any and all thoughts you may have. What parts of the newsletter do you find most valuable? Is there something that you would like to see changed? What would you like to see in future issues? All feedback is appreciated.

## Forum on Education Sessions at the Upcoming March and April Meetings

*John Stewart, Chair Elect – Forum on Education, West Virginia University*

The Forum on Education program committee has completed its work selecting the sessions for the APS April Meeting from January 28-31, 2017 in Washington, DC and the March Meeting from March 13-17, 2017 in New Orleans, LA. The Chair Elect of the Forum on Education is the chair of the program committee. The slate of education sessions developed by the committee is impressive and should be of interest to a broad audience. This year's program committee included Danny Caballero representing the topical group on physics education research (GPER), Mary Mogge representing the American Association of Physics Teachers (AAPT), Nicholas Weingartner representing the Forum on Graduate Student Affairs, Itai Cohen representing the Forum for Outreach and Engaging the Public, Ken Cicire and Bruce Mason who contributed AAPT co-sponsored sessions, Ted Hodapp and Monica Plisch from APS, and Forum on Education Executive Committee members Wendy Adams, Luz Martinez-Miranda, and Heather Lewandowski. Informal invitations have gone out to the speakers who will soon receive a formal invitation from the APS, so a speaker list cannot be announced at this writing; however, session titles can be announced. The meetings will be covered in the order they will actually happen.

### APS April Meeting from January 28-31, 2017 in Washington, DC

**Session 1** - Forum on Education Excellence in Physics Education Award – This session will present this year's award winner and allow FED and GPER APS Fellows from previous years to present an overview of their work.

**Session 2** - Research in Teacher Preparation (co-sponsor with GPER) – This session will provide an overview of the history of and most recent developments in research into physics teacher education.

**Session 3** - Online Communities Supporting Physics Education

(AAPT contributed session) - This session will present a variety of online sources of materials to support physics educators.

**Session 4** - Using 21st Century Physics to Educate 21st Century Students (AAPT contributed session) – This session will present a number of ways that modern physics (nuclear and particle) can be used in the classroom.

**Session 5** - The Cutting Edge of Physics Education Research (co-sponsor with GPER) – This session will feature speakers whose work is pushing forward the boundary of physics education research.

### APS March Meeting from March 13-17, 2017 in New Orleans, LA

**Session 1** - Reichert Award Session – This session will feature the Reichert Award winner and other speakers discussing Advanced Laboratory instruction.

**Session 2** - Preparing Physics Students for 21st Century Careers – This session will feature speakers from academia and industry discussing how to prepare physics students for careers in both the private and academic sectors. It should be of interest to both faculty involved in preparing students and students who want to know what skills industry is looking for.

**Session 3** - The New (and Future) Faculty Workshop in Three Hours – This session will feature speakers who have presented at the APS New Faculty Workshop and speakers who have been instrumental in finding innovative ways to train future faculty. The session should give attendees an overview of the New Faculty Workshop, some new ideas, and possibly a refresher course.

**Session 4** - How to Get a Job: Preparing for a Career in Physics – This session addresses the issue of preparing students for careers

in physics, both within academia and in the private sector, from the view of the student (as opposed to Session 2 which takes the view of faculty). It will feature general discussion of careers in physics and how to find the career you want. It will also feature speakers from industry and speakers who have taken unique career paths. It is meant to be particularly appropriate for the many student (grad-

uate and undergraduate) attendees at the meeting, but also valuable for faculty who wish to understand physics career issues.

As program chair, I would like to thank the committee for all their hard work putting together a fantastic set of sessions that APS members should find very interesting.

## 2017 APS Excellence in Physics Education Award

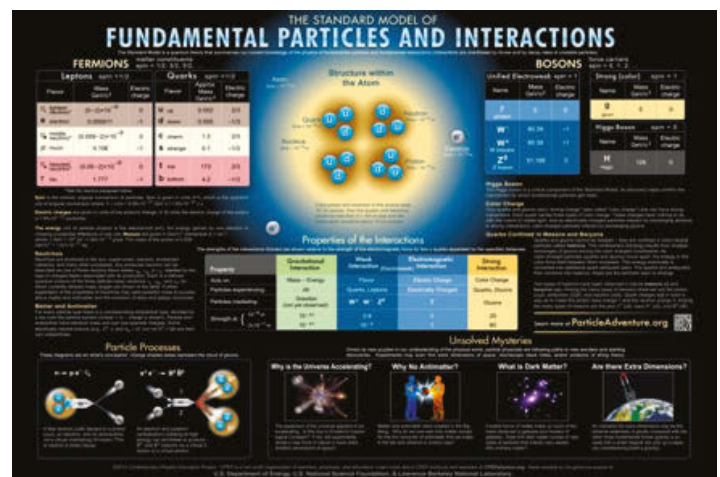
*Wendy Adams, Chair - Excellence in Physics Education Award Selection Committee, University of Northern Colorado*

The selection committee for the Excellence in Physics Education Award had a difficult job this year choosing between several deserving nominations. We would like to extend our appreciation to the efforts of several APS members who submitted these nominations. I would also like to recognize Ken Heller, Vice Chair, Dan Crowe, Dawn Meredith and Robert Beichner (2016 recipient) for their time and efforts in selecting this year's awardee.

The 2017 APS Award for Excellence in Physics Education goes to the Contemporary Physics Education Project (CPEP) <http://www.cpepphysics.org/> for leadership in providing educational materials on contemporary physics topics to students for over 25 years.

Twenty five years ago the Contemporary Physics Education Project (CPEP) created materials to make the key ideas of particle physics and the Standard Model accessible to high school students and the public in general. CPEP began by creating the equivalent of a periodic table for the Standard Model. Since its inception 25 years ago, the project has expanded to include materials for nuclear physics, plasma physics, and cosmology and has impacted millions of instructors and students around the world.

This project has been successful in part due to the quality and effectiveness of materials and the foresight of the group to create a sustainable model for dissemination. CPEP has been attentive to research based practices during the creation of this initial table and other materials. When designing the table, they not only consulted experts to create the draft of the table, but followed up by testing it in high school classrooms and modifying based on feedback



from teachers. The project has since created a web-based “Particle Adventure” which incorporates “chunking” the ideas into easily manageable elements, excellent use of visual aids, and questions to provide formative assessment. The project has been sustainable due to the creation of an international non-profit organization with the mission of supporting the dissemination of quality educational material on contemporary physics.

If you know of a team or group of individuals, or, exceptionally, a single individual, who have exhibited a sustained commitment to excellence in physics education, please nomination them before June 30, 2017. More information can be found at <https://www.aps.org/programs/honors/awards/education.cfm>.

## Director's Corner

*Theodore Hodapp*

For the past three and a half years, the APS Committee on Education (COE) has been considering the many requests APS receives to provide something similar to what the American Chemical Society has been doing for decades, namely to provide undergraduate Program Approval – a de facto form of accreditation. The committee did an extensive survey of department chairs in 2014, and after considerable discussions made a recommendation to the APS Council in 2015 to form a national task force to develop a guide that would provide best practices in the review, assessment, and improvement of undergraduate physics programs. While not an accreditation document or process at this time, the realities of higher education continue to push colleges and universities increasingly toward accountability that follow accreditation standards. Amplifying these concerns is a movement by the ABET organization to accredit all science programs in addition to its current efforts in engineering.

The Committee on Education felt that the creation of such a guide would allow departments to create, improve, and assess their own flexible programs that respond to their local constraints, resources, and opportunities, while being informed by current research and

good practice within the discipline. The aim is to have such a guide also fit into the regular program evaluation cycle experienced by nearly all programs, and give faculty members ideas on how to construct and carry out assessment and evaluation plans that will improve their offerings. Plans are also developing to ensure there are extensive opportunities for feedback from department chairs to create a highly practical document that can be easily understood and implemented by physics faculty. The guide's development will be informed by many existing reports including the forthcoming Joint Task Force on Undergraduate Physics Programs report (due out in October), which is providing advice on preparing undergraduate students for 21st century careers.

The goal, broadly, is to help departments answer challenges they already face with a collection of knowledge and proven good practice. The task force (Best Practices in Undergraduate Physics Programs – BPUPP) will be broadly soliciting input throughout the process, and currently envisions a “living” document that will be updated as the state of knowledge on various aspects improves. Stay tuned for further developments, as we want to make sure this document meets the needs of physics programs of all sizes.

## FFPER: Puget Sound 2016

*Andrew Boudreaux, Western Washington University*

Over four days in June, more than 40 PER practitioners and consumers gathered at the North Cascades Institute's Environmental Learning Center on the shores of Lake Diablo for the 3rd offering of *Foundations and Frontiers in Physics Education Research: Puget Sound*. The conference, modeled after the ongoing FFPER meetings in Bar Harbor, ME, was residential and almost entirely plenary, leading to a vibrant, running dialogue about methodologies, claims and implications of research on student learning in physics. Most participants came from British Columbia, California, Oregon, and Washington state, with a few travelers from as far away as Hawaii and the east coast of the U.S. The group included graduate students, high school teachers, and faculty from 2-yr and 4-yr colleges and universities. Five stimulating plenary talks

provided anchors and jumping off points for discussion that developed during afternoon unstructured time, as participants hiked the surrounding rain forest, and became more free-ranging during late evening meet ups that included games, puzzles, and of course s'mores. To encourage speakers — and all participants — to share their most current ideas, the conference was “off the record.” So, while we cannot divulge specifics, if your interest is piqued, then please join us in the North Cascades for the next offering of FFPERPS, planned for June 2018.

*Andrew Boudreaux is Associate Professor of Physics and Astronomy at Western Washington University. He was on the conference organizing committee of FFPER: Puget Sound 2016.*

## Physics education research and the ‘math methods’ course

Michael Loverude, California State University Fullerton

This work is part of an NSF-funded collaboration with John Thompson (University of Maine), Joe Wagner (Xavier University) and Warren Christensen (North Dakota State University). The project goals are to investigate student learning and application of mathematics in the context of upper-division physics courses. Our project seeks to study student conceptual understanding in upper-division physics courses, investigate models of transfer, and to develop instructional interventions to assist student learning.

Historically PER has primarily focused on introductory-level courses, but in recent years there has been increasing attention to upper-division courses taken primarily by physics majors.<sup>1</sup> One key course taught by most departments remains under-researched (with a few exceptions<sup>2</sup>): the so-called “math methods” course (called MM for this article).

A MM course is generally taught between introductory physics and the core theory courses in the physics major (electricity and magnetism, classical mechanics, and quantum mechanics), focusing on mathematical techniques that students will encounter in these later courses. Typically MM courses focus on a vast list of topics including differential and integral calculus, series, complex numbers, vector calculus, differential equations, and linear algebra. As if this were not sufficient, often MM has additional implicit goals: students are expected to ‘think like a physicist’ when solving problems. Despite its seeming importance, this phrase is not often operationally defined. For this project we have sought to articulate measurable aspects of this idea and study the extent to which students develop appropriate skills in their lower-division coursework. While instructors value these skills, and there has been some previous discussion of them,<sup>3</sup> they are not often explicitly taught or assessed.

A key goal of our larger project is to develop a series of tasks suitable for use in MM, focusing on skills including dimensional / unit analysis, applying limiting cases, using approximations, identifying errors, and predicting the effects of problem changes on the resulting solution.<sup>4</sup> (We do not claim that this list is complete.)

### A. Research Lenses

Every research project chooses appropriate lenses through which it views data and derives conclusions. For this project, we have focused on the cognitive: students’ mental processes, reasoning, and models. Within this realm, there are many appropriate lenses from which to choose. This portion of our project is driven by practice; we are seeking to learn what is difficult for students and develop instructional interventions.<sup>5</sup> A growing body of work in PER has examined student use of mathematics in physics, and researchers have chosen (and developed) a variety of theoretical frameworks in order to interpret their findings.<sup>6</sup>

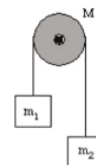
In particular, we refer to two models. Redish described stages of

*modeling, processing, interpreting, and evaluating.*<sup>7</sup> For the specific case of upper-division physics courses, Wilcox et al. proposed the ACER framework, in which students must *activate* the appropriate mathematical tool, *construct* a model, *execute* the mathematics, and *reflect* on results.<sup>8</sup> In each model, successfully executing a mathematical procedure is only one element, but physics courses often focus almost exclusively on processing or executing.

### B. An example of student responses

For this forum, we focus on a single sample task, the *Evaluate the Expressions* task, that is illustrative of the non-procedural skills that we are describing. This task involves the evaluation of mathematical expressions for correctness. The task describes an Atwood’s machine (see figure below), an example that students might have encountered in introductory mechanics. Students are shown three expressions for the acceleration of one of the two blocks and asked to determine whether the expressions could be correct. (All three expressions are incorrect.) The problem is posed on the first day of the MM course on an ungraded quiz and subsequently explored in a group discussion. The problem has been administered in three sections of MM (N = 47) at our university before any instruction and used as the basis of six interviews with students from a different MM course.

Consider the motion of two blocks connected to form an Atwood’s machine. The masses of the two blocks are  $m_1$  and  $m_2$  and the mass of the pulley is  $M$ . The following expressions are proposed for the acceleration of block 1. For each, evaluate whether the expression could be correct and explain briefly:



$$a = \frac{m_2 - m_1}{m_2 + m_1} g \quad a = \frac{m_2}{m_2 + m_1 - M/2} g \quad a = \frac{m_2 - M/2}{m_2 + m_1 + M/2} g$$

A written task in which students are asked to evaluate multiple expressions for possible correctness given a physical situation.

Unlike many problems that students have encountered, this task asks for evaluation (per Redish) or reflection (per Wilcox). Students are not asked to solve the problem and are given no numerical values. Instead they might check limiting values or identify cases in which the expression is unphysical (e.g., in the second expression, if  $M/2 = m_1 + m_2$  the acceleration would be infinite).

This task is challenging for students. Only one student offered a completely correct solution. Ten others identified all three solutions as incorrect but with incomplete or incorrect explanations. Many students (10-20%) gave no response, despite ample time to complete the task. The approaches used by students varied considerably, and while many did attempt to reason with the mathematical expression, others seemed to respond as though this task were a more typical end-of-chapter problem. About 10% of the students solved the problem directly, and others performed algebraic ma-

nipulations of the given expressions. A few students mentioned partially remembered results: “my very rusty memory only recalls subtracting from the bottom.” These responses suggest an epistemological stance that is quite different that the problem intends.

A few responses reflected an attempt to reconcile the mathematical form of the expression with a sense of physical mechanism. Several students referred explicitly to the presence or absence of a term with the difference in masses: “Correct:  $m_2$  is countering  $m_1$  so  $m_1$  is accelerating at a portion of  $g$ .” Such responses are reminiscent of the work of Sherin on students’ reading of equations.<sup>9</sup> A few students gave similar explanations but with respect to other quantities: “this expression raises the value of acceleration as the mass of the pulley increases leading me to believe this is incorrect.” Both cases reflect good reasoning upon which we can build.

The interview responses were particularly illustrative of the issues described above. One student struggled with the task, and was increasingly unhappy with her inability to explain: “sorry that I’m saying I’m not sure for so many of these.” The interviewer then asked what he thought would be a final question: “If I look at the structure of the mathematical expression, the greater the mass of the pulley, what would I expect? What impact would that have on the expression?” The student took up this line of reasoning, revising her previous responses and generating additional examples. When prompted to use reasoning skills instead of procedural knowledge, the student was able to do so very productively, but it did not occur to her that this sort of reasoning would be useful or even allowed.

This portion of the project is in initial stages, but we feel that our preliminary results offer some insights into the MM course. Many students entering the MM course do not successfully reason quantitatively, even when explicitly prompted to do so. Few of the students spontaneously considered special cases of the variables in the problem or related to a sense of physical mechanism. Instruction focused on procedures does not necessarily lead students to develop these reasoning skills that physicists value. There is a need for tasks that can be used in instruction and assessment; developing such materials is one of our ongoing goals.

This research is supported in part by NSF grants PHY 1406035, 1405616, and 1405726.

*Michael Loverude is Professor of Physics and Director of the Catalyst Center at California State University Fullerton. He was a*

*plenary speaker at FPER: Puget Sound 2016.*

(Endnotes)

1. M. E. Loverude and B. S. Ambrose, “Editorial: Focused Collection: PER in Upper Division Physics Courses,” *Physical Review Special Topics in Physics Education Research* **11**, 020002 (2015).
2. For an example of studies in a combined mathematical methods / classical mechanics course, see SEI: Science Education Initiative at University of Colorado Boulder, <http://www.colorado.edu/sei/departments/physics.htm>
3. E. F. Redish, “Problem solving and the use of math in physics courses.” In Conference World View on Physics Education in 2005, Delhi, August 21–26, 2005.
4. M.E. Loverude, “Assessment to complement research-based instruction in upper-level physics courses, 2011 PERC Proceedings [Omaha, NE, August 3-4, 2011], edited by N. S. Rebello, P. V. Engelhardt, and C. Singh [AIP Conf. Proc. 1413, 51-54 (2012), M. E. Loverude, “Surprisingly, there is an actual physical application,” Student understanding in Math Methods, 2013 PERC Proceedings [Portland, OR, July 17-18, 2013], edited by P. V. Engelhardt, A. D. Churukian, and D. L. Jones; and M. E. Loverude, “Quantitative reasoning skills in math methods,” 2015 PERC Proceedings.
5. P. R. L. Heron, “Empirical investigations of learning and teaching, Part I: examining and interpreting student thinking,” *Proceedings of Enrico Fermi Summer School on Physics Education Research*. (pp. 341-350). Italian Physical Society (2003).
6. T. J. Bing and E. F. Redish, “Analyzing problem solving using math in physics: Epistemological framing via warrants,” *Physical Review Special Topics – Physics Education Research* **5**, 020108 (2009), J. Tuminaro and E. F. Redish, “Elements of a cognitive model of physics problem solving: Epistemic games,” *Physical Review Special Topics -Physics Education Research* **3**, 020101 (2007).
7. E. Redish & E. Kuo, “Language of physics, language of math: disciplinary culture and dynamic epistemology,” *Science and Education* **24**, 561-590 (2015).
8. B Wilcox et al, “Analytic framework for students’ use of mathematics in upper division physics,” *Physical Review Special Topics – Physics Education Research* **9**, 0201191 (2013).
9. B. L. Sherin, “How students understand physics equations,” *Cognition and Instruction* **19**, 479–541 (2001).

## An entry S.P.O.T. for reform in the landscape of STEM pedagogy

*Cassandra Paul, San Jose State University*

At the FFERPS conference in the North Cascades this June, I described the development and implementation of Student Participation Observation Tool (SPOT). This work, supported by NSF,<sup>1</sup> has been primarily conducted by my research team at San Jose State University with contributions from colleagues at other institutions. While our research has thus far been focused on the professional development of faculty, we have recently developed an interest in looking at how institutions of higher education evaluate teaching effectiveness as a whole, and what can be done to shift the prevailing academic culture of traditional instruction toward research-based teaching practices, particularly practices involving active learning. This article summarizes the arguments I presented at the meeting, as well as the discussion that followed.

While institutions of higher education, STEM instructors, and education researchers all want what is best for students, different stakeholders use different methods to evaluate teaching effectiveness. These metrics have the potential to work against one another. For example, instructors who use reformed practices in their courses tend to have lower student evaluations than their traditional counterparts, even when student course performance is higher.<sup>2,3</sup> Institutions can thus actually penalize instruction associated with greater student learning. This is especially problematic for overall academic culture, because institutions overwhelmingly use student evaluations to judge teaching effectiveness in the tenure and promotion process.<sup>4</sup>

Physics Education Researchers, as well as other education scholars, agree that interactive engagement techniques are superior to passive modes of instruction in promoting student learning. One way to align institutional and instructor metrics for teaching effectiveness is to collect information about what is actually happening in the classroom, and compare that with the pedagogical expectations of the department, college and university. This can allow faculty members currently using interactive techniques to be rewarded for these efforts. This may encourage other faculty to try something new, as some faculty members cite a lack of institutional rewards as a reason for abandoning reformed teaching methods.<sup>5</sup> While many options exist for collecting information about classroom practice, we argue that SPOT or a similar observation protocol is ideal for this endeavor.

SPOT is a web-based observation protocol that allows an observer to categorize instructor and student actions in real-time by clicking on menu items representing different categories of actions, such as “explaining” or “asking a question.” SPOT’s major strength is that it auto-generates illustrative charts and graphs immediately following an observation, which are easy to interpret. An instructor can then visualize, digest and reflect on how they are spending time in the classroom. In fact, SPOT (like it’s predecessor, the Real-time Instructor Observing Tool, RIOT),<sup>6</sup> was developed predominantly to help instructor-observer pairs collaboratively develop their pedagogical practice.

Direct observations in classrooms are a much more reliable way to get information about what is pedagogically happening during class than student evaluations. Many institutions already use some sort of classroom observation, either as a part of the retention and promotion process, or as a part of voluntary or mandated instructor professional development. Introducing a specific classroom observation protocol may thus be a manageable change in many cases.

Since it may not be practical for a pedagogical expert to visit every class on campus, instructors are often observed by their peers, or supervisors, who generally lack formal training in education. These observers’ views may or may not align with best practices derived from educational research. With SPOT, however, an observer systematically collects information about what actions did and did not occur in the classroom, minimizing impacts of judgment or bias. Since SPOT immediately generates charts and tables, both the instructor and the evaluators are provided with a portrait of classroom practice capable of supporting reflection. Instructors could include SPOT data as part of a dossier or portfolio, perhaps accompanied by a narrative reflection.

Most of the FFERPS audience was enthusiastic about the professional development value of SPOT, with several expressing interest in using it themselves. Some expressed reluctance to use SPOT as an evaluation tool because it measures only the occurrence, and not the quality of interactions. The discussion here centered on the complexity of facilitating active learning, including the need for sensitivity in understanding and responding to student thinking for an activity to promote learning effectively. SPOT, unlike some other observation practices, cannot capture such nuance. However, existing research overwhelmingly indicates that active learning is more effective than (or at least as good as)<sup>7</sup> lecture in promoting sense making. Thus, while using SPOT to rank teaching effectiveness across lessons or courses would not be appropriate, SPOT can provide a first order indication that an instructor is trying to incorporate aspects of active learning into the classroom. Learning to facilitate student-centered instruction is like learning anything: one improves with practice. We argue that using SPOT can *encourage* the adoption of interactive methods, not that it will provide a precise measure of the amount of student learning that occurs. In fact, the SPOT team purposely does not prescribe certain amounts or types of actions as indicative of particular levels of classroom interactivity. SPOT simply provides a picture of what happens.

A second concern was that existing institutional evaluation procedures are sufficient, rendering SPOT unnecessary for evaluation in some contexts. The FFERPS conference participants, as PER consumers and practitioners, already are strongly committed to student-centered instruction. We believe that a primary benefit of including SPOT in the evaluative process is to provide incentive for instructors to take the risk of trying something new. That is, to encourage faculty not already using interactive methods to not



only try them, but to stick with them through the potential implementation dips. We argue that SPOT is most useful NOT as an assessment of the types of instruction the PER community is trying to encourage, but rather as a way to encourage – through assessment – more usage of research-based interactive techniques.

College STEM instruction still largely consists of traditional lecture, poorly aligned with best practices established through research on student learning. We believe that physics educators, as a community, must actively address this issue. Although not necessarily appropriate for every context, SPOT can be a tool useful in supporting the professional development of instructors, and in engaging university administration in supporting such development. As PER matures, we find ourselves more and more able to effect change at the department, college and institutional level. Changes to institutional policy can steer individual instructors toward research-based teaching practices while normalizing such practices in the overall culture of the academy.

Instructors interested in using SPOT to reflect on the interactions happening in their classrooms may email the author at [Cassandra.paul@sjsu.edu](mailto:Cassandra.paul@sjsu.edu) for more information on this continuing project.

*Cassandra Paul is Assistant Professor of Physics and Astronomy*

## Gender gaps - a cautionary tale

*James Day, University of British Columbia*

In research, we strive to be our own most rigorous critic. At the FFERPS conference, I presented a cautionary tale about matching claims to evidence, drawn from work my colleagues and I have done at the University of British Columbia (UBC) investigating possible gender differences in student learning in our first-year physics laboratory course.

The talk presented three main messages. First, while all lab students learn, a gender gap is present both at the beginning and end of instruction. Second, valid and interpretable results are elusive. And third, effect sizes are a robust quantitative measure. The second and third messages are readily found in existing peer-reviewed literature, and are addressed more explicitly below. FFERPS was an opportunity for the community to reflect on and discuss these easily overlooked but critical points.

The talk began with the common assertion that male students outperform females on most physics concept inventories. We wondered whether such a gender gap existed with the relatively new Concise Data Processing Assessment (CDPA),<sup>1</sup> developed at UBC, and whether gendered actions in the teaching lab might influence—or be influenced by—such a gender gap. The CDPA is a ten-question, multiple-choice diagnostic, that probes student abilities related to the nature of measurement and uncertainty, and to handling data. To estimate the gap, and its predictors and cor-

*and the Science Education Program at San Jose State University. She was a plenary speaker at FFERP: Puget Sound 2016.*

(Endnotes)

1. NSF PRIME #1337069
2. J. D. Walker, S. H. Cotner, P. M. Baepler, and M. D. Decker, *CBE-Life Sciences Education* **7**, 361 (2008), URL <http://dx.doi.org/10.1187/cbe.08-02-0004>.
3. M. Braga, M. Paccagnella, and M. Pellizzari, *Economics of Education Review* **41**, 71 (2014), URL <http://www.sciencedirect.com/science/article/pii/S0272775714000417>.
4. C. Henderson, C. Turpen, M. Dancy, and T. Chapman, *Phys. Rev. ST Phys. Educ. Res.* **10**, 010106+ (2014), URL <http://dx.doi.org/10.1103/physrevstper.10.010106>.
5. J. Michael, *College Teaching* **55**, 42 (2007), URL <http://www.jstor.org/stable/27559310>.
6. E. A. West, C. A. Paul, D. Webb, and W. H. Potter, *Phys. Rev. ST Phys. Educ. Res.* **9**, 010109+ (2013), URL <http://dx.doi.org/10.1103/physrevstper.9.010109>.
7. D. E. Meltzer and R. K. Thornton, *American Journal of Physics* **80**, 478 (2012), ISSN 0002-9505, URL <http://dx.doi.org/10.1119/1.3678299>.

relates, we collected student responses before and after instruction. We also observed how students in mixed-gender groups spent their time in the lab.

Analysis of CDPA responses allowed us to make some claims. There is a gender gap on the CDPA, and it persists from the pre- to the posttest. Furthermore, this gap is as big as, if not bigger than, gaps reported for other instruments. Our observations revealed compelling differences in how students divide their time in lab. In mixed-gender pairs, male students tend to monopolize the computer, while female and male students tend to devote equal time to the equipment, and female students spend more time on other activities, such as writing or speaking to peers. We found no correlation between computer use, when students are presumably working with their data, and posttest performance on the CDPA.

But research is never done as cleanly as it is presented. We stumbled, blundered, and gaffed with our analysis, a process made explicit during the talk. A key point of this confessional description involved the assumptions that underlie common statistical tests. In the physics education literature, explicit discussion of such assumptions is often missing. This could be due to a selection effect, in which manuscripts with data that do satisfy the assumptions are the ones published. But it could also be that researchers in some cases leave the assumptions unevaluated. Misapplying statistical

techniques can lead to both type I and type II errors, and to over- or underestimation of inferential measures and effect sizes. Indeed, “the applied researcher who routinely adopts a traditional procedure without giving thought to its associated assumptions may unwittingly be filling the literature with non-replicable results.”<sup>2</sup>

We were certainly guilty of inattention to underlying assumptions in the early stages of our own data analysis. Ironically, such neglect is consistent with the demonstration of a broad lack of knowledge about the assumptions, the robustness of the techniques with regards to the assumptions, and how or whether the assumptions should be checked.<sup>3</sup> Our initial identification of a gender gap in the CDPA data left us wondering what impact, if any, our lab curriculum was having on student performance. How was the gender gap changing over time? To investigate, we rather blindly followed the well-worn path of examining measures of gain, somewhat arbitrarily deciding in advance that we would use one particular measure. Fortunately, we also decided to do a quick comparison with a second measure as a sanity-check. Inconsistency led to a crumbling of our understanding of these gain measures, and we began to look at a wide variety of alternatives. In total, we examined five separate measures of gain: the average normalized change<sup>4</sup>  $\langle c \rangle$ ; the average absolute gain normalized by the total test score  $\langle g_{\text{abs}} \rangle$ ; the course average (Hake’s) normalized gain<sup>5</sup>  $\langle g \rangle$ ; the absolute gain normalized by twice the average of the pre- and post-test  $\langle g_{2\text{av}} \rangle$ ; and the relative change, which is the absolute gain normalized by the pre-test score  $\langle g_{\text{rel}} \rangle$ . To be clear, then, the differences between these metrics lies in the denominator, in how each is normalized. We found that male students’ scores showed higher apparent learning gains than females’ *only when normalized change was used!* With Hake’s normalized gain, or any of three other reasonable metrics, the statistical significance vanished and the effect size approached zero (perhaps even changing sign!).

We concluded that none of these gain measures were appropriate as estimates of learning for our situation. Although female students clearly were starting and ending at lower levels of achievement, we had no clear picture of whether or not the *amount* of learning was comparable, a finding and question which has been encountered and wrestled with before.<sup>6</sup> Gain scores must be treated with great care; it may be that simply avoiding them altogether is the best path. When different measures applied to the same raw data lead to different narratives about what is happening, we may be better served by reframing the research question. Asking whether one gender has learned more than another is fraught with tacit premises. Instead, we can ask whether there is a gender difference on post-test scores after having considered (some of the) differences with which female and male students begin the course. With that,

the talk argued for the use of analysis of covariance (ANCOVA) as a step in the right direction.

In addition to urging researchers to explicitly check the assumptions associated with their statistical methods, we further call for improved reporting and contextualization of effect sizes.<sup>7,8</sup> In our own case, we decided to make no claim that female students are learning less than their male peers in our lab program. The interested reader can now find this work in peer-reviewed form.<sup>9</sup>

*James Day is Research Associate at the Quantum Matter Institute and Department of Physics and Astronomy at the University of British Columbia. He was a plenary speaker at FFPER: Puget Sound 2016.*

#### (Endnotes)

1. J. Day and D. Bonn, “Development of the concise data processing assessment,” *Physical Review Special Topics-Physics Education Research*, **7**(1), 010114-1:14 (2011).
2. H. J. Keselman, C. J. Huberty, L. M. Lix, S. Olejnik, R. A. Cribbie, B. Donahue, R. K. Kowalchuk, L. L. Lowman, M. D. Petoskey, J. C. Keselamn, and J. R. Levin, “Statistical practices of educational researchers: An analysis of their ANOVA, MANOVA, and ANCOVA analyses,” *Review of Educational Research*, **68**(3), 350-386 (1998).
3. R. Hoekstra, H. Kiers, and A. Johnson, “Are assumptions of well-known statistical techniques checked, and why (not)?,” *Frontiers in Psychology*, **3**, 137 (2012).
4. J. D. Marx and K. Cummings, “Normalized change,” *Am. J. Phys.*, **75**, 87-91 (2007).
5. 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**, 64-74 (1998).
6. S. D. Willoughby and A. Metz, “Exploring gender differences with different gain calculations in astronomy and biology,” *American Journal of Physics*, **77**(7), 651-657 (2009).
7. G. M. Sullivan and R. Feinn, “Using effect size-or why the P value is not enough,” *Journal of Graduate Medical Education*, **4**(3), 279-282 (2012).
8. J. M. Maher, J. C. Markey, and D. Ebert-May, “The other half of the story: effect size analysis in quantitative research,” *CBE-Life Sciences Education*, **12**(3), 345-351 (2013).
9. J. Day, J. B. Stang, N. G. Holmes, D. Kumar, and D. A. Bonn, “Gender gaps and gendered action in a first-year physics laboratory,” *Physical Review Physics Education Research*, **12**(2), 020104-1:14 (2016).



## Teacher Preparation Section

*Alma Robinson, Virginia Tech*

As readers of the Teacher Preparation Section know, we often feature articles describing the fantastic teacher preparation programs that are being implemented at PhysTEC supported sites. For the next few issues, however, we wanted to highlight practices and programs that have found ways to recruit and train future physics teachers without the benefit of PhysTEC funding.

David Griffiths describes how Reed College hosted a panel discussion on high school physics teaching during one of their weekly seminars. They invited local physics teachers (some of whom were Reed alumni) to serve on the panel and speak about their experiences in the classroom. Through this discussion, both faculty and students gained a better understanding of what a high school physics teaching career might look like, including job opportunities and certification requirements.

Steve Campolo and Harold M. Hastings discuss the development of Hofstra University's "Make-it" class, a course dedicated

to having students (including preservice physics teachers) construct complicated electrical projects from scratch. This student-centered, active-learning lab course helps students understand the design process, develop fabrication skills, and learn how to apply their content knowledge to create a tangible product.

Donna Stokes, Paige Evans, Cheryl Craig, and Simon Bott explain how The University of Houston's (UH) Robert Noyce Scholarship Program: Recruitment, Preparation and Retention of Teachers for Secondary Physics and Chemistry Education provides an array of programs and opportunities to UH's preservice science teachers, including targeted coursework, internships, professional development, and scholarship support.

Finally, the 2017 PhysTEC conference will be held on February 17-18th in Atlanta, GA, preceding the AAPT Winter Meeting. Please see <http://www.phystec.org/conferences/2017/> for more information.

## Encouraging Students to Pursue Careers in Teaching

*David Griffiths, Reed College*

For years I have been dismayed at how few of our physics majors go into high school teaching as a career. Part of the problem is the mindless teacher training and certification process they would have to endure. (Many years ago the state of Oregon deliberately killed Reed's outstanding MAT program; the last straw was a requirement that we offer a course on "personal finance"—how to balance your checkbook—and the Reed faculty rightly refused.) But another impediment is that none of us on the faculty know much about high school teaching, so we could offer little useful advice or support (and, to be honest, we tended to convey an impression that anything short of a PhD in physics represented a kind of failure).

So when I read the *APS News* article by David Meltzer, Monica Plisch, and Stamatis Vokos (August/September 2013), it occurred to me that we should invite some local teachers to present a panel discussion at one of our weekly seminars. Rounding up the speakers was surprisingly easy. Two of them were Reed alumni, one had worked at Reed as a summer intern, and the fourth was my son's (excellent) teacher at the nearby high school. They were a perfect

mix: two women, two men; three mid-career, one just starting out; two from public schools, two from private schools; three current classroom teachers, one now in administration. Two of them had recently sent outstanding graduates to Reed.

In my invitation I wrote, "I'm hoping each of you will speak for 5-10 minutes, leaving plenty of time for questions and discussion. The main purpose is to plant the idea that [high school teaching] might be an interesting career. Our students know nothing about it (except what they may have picked up by being on the receiving end). So anything you can tell them about how you got into it, what training and credentials you needed, what it's like as a career (the good and the bad, pleasures and frustrations), and above all what it's like to be in the classroom on a daily basis (preparation, discipline, how to explain things at this level, use of mathematics, role of lab, etc.)—whatever you think would be useful and interesting." I asked the administrator to talk as well about job opportunities in the field and what she looks for in an applicant.

My main worry was that nobody would come. This was a very unusual seminar for us (ordinarily they are straight physics), and it would not have surprised me if students and faculty both had stayed away. I did do some extra “advertising”—alerting the Career Services office and specifically inviting the other science departments. Fortunately, the room was packed (certainly over 50), and it included all the usual physics students (mostly juniors and seniors) and faculty (seven of us). The speakers were excellent: articulate, informative, and nicely complementary, even though we had not coordinated their presentations beforehand. We took them out to dinner afterward, and it was clear that they were thrilled to have this opportunity to talk about their careers (and, I believe, honored to have been invited).

Exactly how much impact it had is hard to say. Several students stayed after the seminar to ask more detailed questions, so there was clearly some genuine interest. The speakers did not act like recruiters—they were perfectly frank about the irritations as well as the joys of teaching. But they did convey a palpable enthusiasm

and excitement that had to leave a strong favorable impression. Last year one of our graduates won a prestigious Woodrow Wilson Fellowship, which provides training and a stipend for aspiring teachers in STEM fields; he told me that the seminar had inspired him. I know of one senior this year who is planning a career teaching high school physics, but as far as I know she was not present at the seminar (she would have been a sophomore then). I think I would call the program a success, but really it needs to be repeated every year or two, and I was gratified to learn that a rerun with a different cast of characters is planned for this spring.

*David Griffiths is Emeritus Professor of Physics at Reed College where he taught physics for 35 years. His PhD was in particle theory (Harvard, 1970). He is the author of three textbooks: Introduction to Electrodynamics, 4th ed. (Pearson, 2013), Introduction to Quantum Mechanics, 2nd ed. (Cambridge, 2017), and Introduction to Elementary Particles, 2nd ed. (Wiley-VCH, 2008), and a book for general readers, Revolutions in Twentieth-Century Physics (Cambridge, 2013).*

## Fabrication Technology for Physics Students: The Make-it Class

*Steve Campolo, Hofstra University*

*Harold M. Hastings, Bard College at Simon's Rock and Hofstra University*

*“With the skills that I developed in this class, I went on to build a Tesla coil of my own, for use in demonstrations in the high school physics class I currently teach.” - Nicole Spinelli, now a Secondary School Teacher and Adjunct Instructor of Physics teaching labs at Hofstra University*

We describe our implementation of a “Make-it” class to complement the traditional Junior Lab for Physics majors, joint Physics and Education majors, and other STEM students and present an initial, informal assessment of its effects upon their development and career path. Students learned to apply critical thinking toward practical applications of science and began to understand how to bring practical learning into the classroom using a hands-on approach by constructing a professional looking electronic project from scratch.

The Junior Lab in Physics is intended to bridge the gap between introductory laboratories – which are designed to teach and reinforce concepts and the experimental method, as well as to provide the students with an introduction to laboratory techniques – and the demands of experimental research. As Chair of a small but reinvigorated and growing department, one of us (HMH) faced the challenge of re-starting and running a good, useful Junior Lab experience for very small enrollments. At the same time, this challenge seemed to offer an opportunity. Although traditional Junior Labs typically involve more complex experiments than introductory labs, many still use laboratory “kits.” As good as these packaged labs are, they cannot meet important learning objectives for

Physics – Secondary Education majors. Objectives also important to students aiming for careers in the sciences with or without graduate education are:

- The ability to develop or modify laboratory apparatus,
- An understanding of the process of design (understand/adapt/implement), assess, redesign, repeat until success,
- Critical fabrication skills.

This led to our initial approach: to develop and perform a “classic” measurement from scratch – in this case, the unit of quantized conductance. This approach offers the potential of a more active and satisfying experience, as well as a greater development of “lab shop” skills, but it may also carry a higher risk of failure. With the supervision of HMH, Mark Sheingorn, a Physics and Education major, found the unit of quantized conductance to be approximately 12,300 ohms using apparatus that he developed and built.<sup>1</sup>

We offered the first Make-it class, consisting of three projects, to eight students in 2011. For the first two projects, students worked in teams to construct a simple cloud chamber (a fish tank with an electrically heated, alcohol-soaked felt pad on top and dry ice on the bottom) and a simple version of the MIT Haystack Observatory “very small radio telescope”<sup>2,3</sup> to observe radio emissions from the sun, with the addition of a simple, steerable mount, but no interferometer. The third project was to fabricate a regulated, variable voltage DC power supply in a professional-looking plastic housing. Students learned soldering, wiring, and fabrication skills



Nicole Spinelli displaying her professional looking power supply.

in addition to applications of elementary circuit theory. Finally, students took their power supplies home, providing direct, personal experience with ownership of their work. One student, Emma Katz, removed the batteries from her calculator, set the power supply to 6 volts, and connected the test leads to the battery terminals. "It works" Emma exclaimed upon seeing the display light up.

The 2011 course proved too ambitious, so the 2012 course taught by SC focused on a single project: the fabrication of a variable, regulated DC supply. This provided a more unified and deeper student experience, in particular a closer connection between theory and practice. For example, students learned more about materials used in fabrication and the role of accurate measurement. As before, students gained ownership of their learning through construc-



Student Emma Katz (foreground) powering her calculator.

tion of a professional looking and functioning project that they built. After receiving student feedback, we decided to replace this project with the construction of a battery-operated mp3 amplifier that could be connected to a smart phone.

Make-it and an analogous Circuits lab are each 1 credit hour. These labs are not intended to replace engineering labs, but rather to expose students who would not normally take engineering lab courses to practical and applied science. The Circuits lab is an analogous extension of the Electricity and Magnetism course, providing complementary experience in construction and experimentation. Students construct RC timing circuits, transistor switches, transistor amplifiers, and then a transistor oscillator using their RC circuit for timing. Finally, students build integrated circuit amplifiers and oscillators and learn how gain is multiplied in cascaded amplifiers.

Materials for these courses cost approximately \$100 per student. A basic machine shop can be equipped for under \$10,000, but much can be accomplished with hand tools. Details and syllabi can be obtained from the corresponding author, SC.



Make-it class with mp3 amplifiers

**Outcomes.** Several physics majors entered the engineering workforce after graduation. One, a quality engineer in the aerospace field, reported that the experience of becoming familiar with the oscilloscope was invaluable to him. A student employed by an electronics firm was told after being hired that his explanation of his Make-it project set him apart from other job applicants. High school teacher and adjunct instructor Nicole Spinelli stated "The highly effective nature of this course reinforces that though it is important to learn, being capable of building something with what you have learned should be the true goal of education," her own version of Feynman's famous quote "What I cannot create, I do not understand."<sup>4</sup> Another electrical engineer explained his experience

as follows: “The course was essential to me in both my college and professional career. Now that I am pursuing a career in electrical engineering I use skills gained in the class on a daily basis.”

Annual enrollment has grown slowly and steadily from eight students in 2011 to 10-16 students in recent years. Most Physics majors take at least one of the Make-it and Circuits classes.

Hofstra University is a primarily undergraduate institution with total enrollment of 11,000, including 7000 undergraduates with an average SAT of 1180. The Department of Physics and Astronomy has eight full-time faculty members and 30-35 physics majors.

*Steve Campolo is Adjunct Associate Professor of Physics and Laboratory Director. He is also Vice President – Engineering at Leviton Manufacturing Company and holds 33 US patents for electro-mechanical devices. Harold M Hastings is Professor Emeritus and former Chair of Physics at Hofstra, and adjunct faculty in Science at Bard College at Simon’s Rock. He co-founded two medical de-*

*vice companies. Both are radio amateur “hams,” KA2YHY and KD2OH, respectively.*

(Endnotes)

1. H.M.Hastings, and M. Sheingorn, The Junior Lab: A Case Study, Poster presentation at 2007 PhysTEC meeting, <http://www.phystec.org/document/ServeFile.cfm?ID=4959&DocID=238&DocFID=270&Attachment=1>.
2. A. Rogers, P. Pratap, and D. Fields, Science and Technology through Radio Astronomy Experimentation for Community Colleges, Award Abstract #0535839, [http://www.nsf.gov/awardsearch/showAward?AWD\\_ID=0535839](http://www.nsf.gov/awardsearch/showAward?AWD_ID=0535839).
3. MIT Haystack Observatory Undergraduate Research SRT Interferometry, <http://www.haystack.edu/edu/undergrad/srt/index.html>.
4. J. Gleick, *Genius: The life and science of Richard Feynman*. Vintage, New York, 1992.

## Recruitment, Retention and Preparation of Secondary Physics and Chemistry Teachers

*Donna Stokes, University of Houston, Paige Evans, University of Houston, Cheryl Craig, Texas A&M University, Simon Bott, Swansea University*

The National Science Foundation’s Robert Noyce Teacher Scholarship Program provides scholarships for the recruitment and preparation of STEM majors and professionals for teaching careers at elementary and secondary schools across the country. Currently, 67% and 61% of teachers teaching physics and chemistry, respectively, in grades 8 – 12 nationwide, do not hold a degree or a minor in that subject.<sup>1</sup> The University of Houston (UH) Robert Noyce Scholarship Program: Recruitment, Preparation and Retention of Teachers for Secondary Physics and Chemistry Education provides highly qualified physics and chemistry teachers to 24 school districts in the Houston Metropolitan area. UH, a minority-serving institution located in the fourth largest city on the nation, is the second most diverse institution in the nation as rated by US News and World Report.<sup>2</sup> This makes it an ideal location for preparing a diverse pool of STEM teachers for educating future physicists, engineers, computer scientists, chemists, and medical doctors who can contribute to scientific advances and discoveries.

The UH Noyce program is a collaborative effort of the College of Natural Sciences and Mathematics (NSM); the *teachHOUSTON* (tH) program, a teacher certification program for NSM majors; the College of Education; and local school districts. Junior and senior level physics/chemistry majors/minors and post-baccalaureate students can apply for the \$12,000/year Noyce scholarship. Following graduation, students who accept the scholarship are required to complete two years of service in a high-need school district for each year of scholarship support they received. In ad-



ExxonMobil Bernard Harris Summer Science Campers and Noyce Interns

dition, the program supports lower division undergraduate paid summer internships for a 6-week experience: two weeks in an Internship Professional Development Training Institute and 4 weeks working as counselors/teaching assistance to science master teachers for two summer camps: the ExxonMobil Bernard Harris Summer Science Camp (EMHSSC), an academic, residential camp that provides activities, experiments, projects, and field trips for underserved students entering 6th, 7th, or 8th grade; and the Cougar STEM Camp, for 5th – 7th grade students which

features themed weeks exploring STEM topics through hands on activities. The summer internship program serves as a recruiting tool for *teachHOUSTON* and the UH Noyce scholarship program; it introduces STEM majors to teaching and provides professional development activities early in their careers.

Effective practices of the scholarship and internship program include:

(1) Utilization of specialized degree programs for physics/chemistry majors/minors that incorporate core major and teacher certification courses. In particular, the BS Physics degree with the *teachHOUSTON* option and the BS Math major with the physics minor have increased the number of teachers trained in physics at UH. These programs are designed for degree completion and teaching certification within 4 years, making them attractive to STEM majors interested in teaching.

(2) Built in professional development activities. The Internship Professional Development Training Institute, for example, is conducted for Noyce interns two weeks prior to the start of the camp and includes training in classroom management, working with middle school students, college career readiness, and the use of technology.

(3) Cohort building through *teachHOUSTON* and a “Science By Inquiry”<sup>3</sup> course that focuses on increasing the pedagogical content knowledge of our preservice teachers through instructional strategies grounded in best practices and inquiry-based teaching pedagogies – a key for retention. This course is required in the degree plan of all Noyce scholars and can be used as a teacher certification course for all other *teachHOUSTON* students, resulting in a larger number of teachers trained to effectively teach physics.

(4) Intense mentoring both during and after program completion, which is essential for retention in the *teachHOUSTON* program and to the STEM teaching profession. Research has shown that 55% of math/science teachers in Texas leave the teaching profession within their first two years of service with over 50% of all teachers leaving the profession by their fifth year.<sup>4</sup>

The program has awarded 29 scholarships to physics/chemistry majors/minors and 37 internships to freshman/sophomore NSM



First Cohort of Noyce Scholars-Awarded in Fall 2012



Cohort Building through the Science By Inquiry Course

majors. To date, seventeen Noyce Scholars have graduated and are teaching or have received teaching positions in high need school districts; 100% completed their degrees within 6 years with a 4.5-year average. Ten graduates are certified to teach physics – as compared with the previous decade where UH had not graduated any students certified to teach physics. Twelve Noyce Scholars are still in the *teachHOUSTON* program, and thirty-seven interns served as camp counselors in the EMBHSSC. All but three interns are still enrolled in the *teachHOUSTON* program, and five interns have received Noyce scholarships. Overall, the combined retention rate to the *teachHOUSTON* program of the Noyce Scholars and interns is 94% (62/66). Incorporation of the Science By Inquiry course has led to 12 students pursuing the Science Composite Certificate, strengthened the physics content knowledge for students not majoring/minoring in physics, and built a learning community. Due to the course’s success, a similar course was created for preservice middle school teachers and has been offered for the past two years. Additionally, a Biochemistry By Inquiry course is being developed for better preparation of *teachHOUSTON* students’ pedagogical content knowledge in biology and chemistry.

The scholarship and internship support are used to attract, train, and retain STEM majors in preservice teacher preparation programs; however, the program’s collaborative efforts, built-in support mechanisms, and mentoring are necessary components for program sustainability. For example, the specialized degree programs must be approved and promoted by both entities, making the collaboration between STEM Departments and the *teachHOUSTON* program a necessity. The content specific “Science By Inquiry” course has been incorporated into the BS physics degree program with the *teachHOUSTON* option and is approved as a qualifying teacher certification course by the *teachHOUSTON* program. Curricular and professional development activities and mentoring have become integral parts of the teacher certification and major programs, making them sustainable even if the scholarship/internship support is not available.

The UH Noyce program has provided opportunities for research-

ers to develop, implement, and evaluate instructional strategies and inquiry models of teaching for the training of qualified physics and chemistry teachers. Resources developed through this program, i.e., degree plans and professional development tools such as the Internship Institute Training Guidelines, are available on the program's website <http://phys.uh.edu/undergraduate/noyce-scholarship/>. Key outcomes and highlights of the program have been shared through presentations at local, national and international conferences, a research handbook chapter, an international book chapter on teacher education, and two digital stories highlighting best teaching practices.

This work was supported by the National Science Foundation DUE Award -1240083.

*Donna Stokes is an associate professor and undergraduate academic advisor for the Department of Physics. She serves as the*

*principal investigator for the University of Houston Robert Noyce Scholarship Program: Recruitment, Preparation and Retention of Teachers for Secondary Physics and Chemistry Education program.*

(Endnotes)

1. *National Academy of Sciences: Rising above the gathering storm: Energizing and employing America for a brighter economic future*, National Academy Press, Washington DC, (2007).
2. US News and World Report Higher Education: Campus Ethnic Diversity - <http://colleges.usnews.rankingsandreviews.com/best-colleges/rankings/national-universities/campus-ethnic-diversity> (2016).
3. Materials taught in the spirit of L.C. McDermott and the Physics Education Group at the University of Washington, *Physics by Inquiry* (John Wiley & Sons, NY1996)."
4. Fuller, E., "Mathematics and Science Teachers in Texas: Supply, Demand, and Quality," *Texas Instruments & TBEC* (2009).



## Browsing the Journals

Carl Mungan, *United States Naval Academy*, [mungan@usna.edu](mailto:mungan@usna.edu)

- A wonderful comparison of pinhole images of the sun projected onto a wall by openings in a tree before and during a partial solar eclipse can be found on page 259 of the May 2016 issue of *The Physics Teacher* (<http://scitation.aip.org/content/aapt/journal/tpt>). Another lovely photograph in the same issue is of a chain fountain on page 320. David Keeports presents some optics-based tricks to correct near- or far-sightedness without glasses on page 375 of the September 2016 issue.
- In the June 2016 issue of *the American Journal of Physics* (<http://scitation.aip.org/content/aapt/journal/ajp>) John Lekner works out the charge ratio as a function of distance of separation of two like-charged (but different radius) metal spheres that will cause them to attract (rather than repel) due to their mutual polarization. An article of page 413 of the same issue makes the provocative claim that many counterclockwise thermodynamic cycles are not refrigerators. A paper by Robert Hilborn in the July 2016 issue shows that glib statements in an introductory course about electromagnetic field energy being the mechanism for exchange between charges are seldom helpful and often flat out wrong; it is preferable to stick instead to the potential energy of the configuration. A systematic approach to the problem of determining the general shapes of noncircular wheels rolling smoothly on nonflat roads is presented on page 581 of the August 2016 issue.
- Article 045002 in the July 2016 issue of the *European Journal of Physics* hypothesizes that the reason a cat can survive falls from small or large heights but not from intermediate values (corresponding to about the seventh floor of a building) is because the jerk has a maximum for a descent of 20 m, causing a cat to stiffen with fear. In the May 2016 issue of *Physics Education*, de Carvalho considers some contradictions in the force and torque balance of a two-pan scale. In the July 2016 issue, Marciotto calls for an improved derivation of Bernoulli's principle in the introductory course. Both journals can be accessed at <http://iopscience.iop.org/journals>.
- Page 429 of the May 2016 issue of *Resonance* has an article discussing some errors in the Feynman Lectures on Physics about crystal symmetries. Page 447 of the same issue considers the paradox that, due to the shell theorem, there would be no gravitational force in an infinite homogenous universe. Finally page 453 shows that a cube of heavy ice would sink in ordinary water, unlike what a cube of ordinary ice does; dying the cubes with food coloring makes for a nifty demo. A special issue in the June 2016 issue on Hamilton reviews his work on optical wavefronts on page 511 and on quaternions on page 529. These articles can be freely accessed at <http://www.ias.ac.in/listing/issues/reso>.
- An article on page 1289 of the July 2016 issue of the *Journal of Chemical Education* discusses a detailed lab to investigate the bandgap, doping, and structure of light-emitting diodes. Pages 1340 to 1352 of the August 2016 issue has a great set of science book reviews by four different readers, including "What Every Science Student Should Know" and "Seven Brief Lessons on Physics." Pages 1441 to 1451 of the same issue describes two (admittedly lengthy) experiments to prepare and characterize nanoparticle-based materials. Finally the September 2016 issue has an article on page 1578 applying the variational method to calculating bonding and antibonding orbitals of hydrogen molecules starting from Gaussian trial wavefunctions. The journal archives are at <http://pubs.acs.org/loi/jceda8>.
- Article 010135 in *Physical Review Physics Education Research* at <https://journals.aps.org/prper/pdf/10.1103/PhysRevPhysEdu-Res.12.010135> compares three different approaches to teaching wave optics to introductory students: by sketching sinusoidal waves, via snapshots of the electric field at various instants, or by using phasors.



## Web Watch

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- The *Atlantic magazine* has a technology webpage at <http://www.theatlantic.com/technology/>.
- The website <http://stemcareer.com/> exists to promote jobs in science and technology. Also check out the National Informal STEM Education network at <http://www.nisenet.org/>.
- A well-organized collection of the best science blogs is online at <http://scienceblogs.com/>. Johns Hopkins has a blog on innovative instructional practices at <http://ii.library.jhu.edu/>. Also see New Zealand's SciBlogs at <http://sciblogs.co.nz/>.
- Periodically it is useful to review the Khan Academy tutorials in physics at <https://www.khanacademy.org/science/physics>.
- An article from *ScienceNews* discusses the thermodynamics of nanoscale heat engines at <https://www.sciencenews.org/article/ultrasmall-engines-bend-second-law-thermodynamics>. Also see the article on simultaneously maximizing power and efficiency of a heat engine at <http://phys.org/news/2016-05-geometric-simultaneously-maximizes-power-efficiency.html>.
- A useful resource to electronically send large computer files is <http://www.dropsend.com/>.
- Chalkdust at <http://chalkdustmagazine.com/> is described as a magazine for the mathematically curious.
- You have probably seen kids practicing the water-bottle-flipping trick. Videos and an explanation of the physics are online at <http://www.vox.com/2016/5/26/11785562/water-bottle-flip-physics>.
- Giphy at <http://giphy.com/create/gifmaker> is a tool to create animated GIFs from videos such as YouTube.
- MIT has a helpful set of links to online physics resources at [https://blossoms.mit.edu/resources/physics\\_resources](https://blossoms.mit.edu/resources/physics_resources). Similarly the Space Science Institute has online astronomy resources at <http://www.space-science-institute.org/educationresources.php>.
- Teaching tools for STEM education with particular focus on the Next Generation Science Standards are available at <http://stem-teachingtools.org/>. University of Cambridge resources for teaching A-level math are organized into a subway-style map starting at <https://undergroundmathematics.org/>.
- NOVA's interactive archives on physics and math are worth a browse at [http://www.pbs.org/wgbh/nova/hotscience/int\\_phys.html](http://www.pbs.org/wgbh/nova/hotscience/int_phys.html).
- Voyant has a tool to analyze your technical writing in various ways at <http://voyant-tools.org/>. For example, it creates a colorful map of keywords that might enhance your next powerpoint presentation.
- APS is changing from PACS codes for journal articles to Subject Headings, as described at <https://physh.aps.org/about>.
- NSF has a set of 62 science videos showcased online at [http://stemforall2016.videohall.com/presentations#/keyword/ids=k\\_111](http://stemforall2016.videohall.com/presentations#/keyword/ids=k_111).
- Got Science is an online publication of tech news at <http://www.gotscience.org/category/physics-on-gotscience/>.
- An optomechanical transducer that converts signals between optical, acoustic, and radio frequencies is described at <http://phys.org/news/2016-03-multilingual-circuit-optomechanical-transducer-links.html>.
- Stanford and UBC have an article about improving critical thinking in the introductory lab course at <http://news.stanford.edu/2015/08/17/thinking-holmes-wieman-081715/>.
- Finally, Rhett Allain analyzes one's ideal running speed to conserve energy at <https://www.wired.com/2016/09/whats-ideal-running-speed-conserve-energy/>.

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#### *Upcoming newsletter deadlines:*

Spring 2017: January 13th, 2017

Summer 2017: June 1st, 2017