

# Forum on Education

American Physical Society

## Spring 2019 Newsletter

*Richard Steinberg, Editor*

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## From the Chair

*Laurie McNeil, University of North Carolina at Chapel Hill*

It is my pleasure to address members of the Forum on Education (FEd) for the first time in my role as Chair. I do so a bit earlier than did my predecessors as a result of the change in the Forum's bylaws that shifts the beginning of the terms of office for officers and members of the Executive Committee from April to January. That means that Larry Cain's term as Chair lasted only eight months, but I am deeply grateful to him for his contributions to the Forum. I look forward to benefitting from his wise counsel during his (12-month!) term as Past Chair. Both of us would like to thank John Stewart (stepping down from the post of Past Chair) for his service during his four years as a FEd officer, in particular for his careful management of the revisions to the Forum's bylaws.

The new year brings additional arrivals, changes, and departures among the FEd leadership. Jerry Feldman, formerly Vice Chair, has now become Chair-Elect for 2019. He will also serve as Program Chair for the FEd sessions at the 2020 March and April meetings, so please send him ideas for session themes and speakers relevant to education. In his place we welcome our new Vice-Chair for 2019, Catherine Crouch (Swarthmore College). Leaving the Executive Committee with our hearty thanks for their contributions are Luz Martinez-Miranda and Toni Sauncy. They will be replaced by Adrienne Traxler (Wright State Univ.) and Benjamin Dreyfus (George Mason Univ.), who will serve three-year terms as Member-at-Large and APS/AAPT Member-at-Large (respectively). For the first time we also welcome a Graduate Student Member-at-Large, Julian Gifford (Univ. of Colorado), whose term will be for two years. I appreciate the willingness to serve displayed by all of these colleagues and anticipate that the discussions at Executive Committee meetings in coming years will be lively and productive.

I would also like to thank Richard Steinberg for his three years as Editor of this newsletter. Our Forum's newsletter is the envy of other Forums and Richard leaves it in exemplary condition. Throughout his tenure he has carried out his tasks with professionalism, flexibility, attention to detail and good humor. We anticipate that our new Editor, Jennifer Doktor (Univ. of Wisconsin - La Crosse), will follow in Richard's footsteps and keep the newsletter at its current high standard. We welcome Jennifer and look forward to future newsletters bearing her imprint.

I am looking forward to the ceremonies at the March and April

meetings at which the winners of APS Awards related to education will be honored. The 2019 Jonathan F. Reichert and Barbara Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction will be presented at the March meeting in Boston to Heather J. Lewandowski *for systematic and scholarly transformation of advanced laboratories in physics, for building leading assessment tools of laboratories, and for national service advancing our advanced laboratory educational community.* (See below for an additional honor for Dr. Lewandowski.) She will speak about her work on Tuesday afternoon in an invited session entitled "Incorporating State-of-the-Art Research into Advanced Labs." Also speaking in that session will be Benjamin Zwickl, Chad Hoyt, Sara Callori, and Joseph Kozminski. At the April meeting in Denver APS will honor the winners of the 2019 Excellence in Physics Education Award: Steven Pollock, Steven Iona, Laurie S. Langdon, Valerie K. Otero, and Richard McCray, *for the development of the Learning Assistant (LA) model and the associated LA Alliance, which has enhanced physics teacher education and recruitment, supported undergraduate course transformation, and physics instructor professional development.* All the recipients except Dr. McCray will participate in two talks at an invited session on Tuesday afternoon entitled "The Learning Assistant Alliance." They will be joined by Mel Sabella, who will present a third talk on Learning Assistants.

At both the March and April meetings there will be an Education and Diversity Reception at which we will honor the new APS Fellows nominated by the Forum: Diola Bagayoko (Southern University and A&M College), Amy L. R. Graves (Swarthmore College) and Heather Lewandowski (University of Colorado, Boulder). We hope to see you there!

As always, if you have any thoughts about what the Forum is doing (or should be doing) on behalf of physics education, please feel free to contact me or any of the members of the Executive Committee. And consider nominating a deserving colleague for one of the Awards mentioned above, or for APS Fellowship. We all know that recognition for excellence is a precious thing, and contributions to education are too often overlooked. Get in touch with me if you have a candidate in mind but are not sure how to navigate the APS nomination process.

I wish you a happy, healthy, and productive 2019!

## From the Editor

*Richard Steinberg, City College of New York*

This issue marks the last as my term as editor of the Forum on Education Newsletter. I am grateful to have had the opportunity to learn from so many people doing so many wonderful things to forward the goal of improving physics education. I am thankful to the many people who have supported my role as editor including article authors, FEd committee members, *Teacher Preparation Section* Editor Alma Robinson, and *Browsing the Journals* and *Web Watch* author Carl Mungan.

I have enjoyed presenting diverse themes and articles that speak to the myriad of topics important to the big picture view of phys-

ics education. For this issue, I have taken the opportunity to invite contributions from some of those who I had not yet invited to contribute but who have been so successful in improving physics education in different ways. My goal is to have articles in which forum members may be inspired and/or informed on how to take specific action. Topics include influencing policy, supporting teachers, and transforming undergraduate education. These articles document the great impact that many members have had and *all* can have through lobbying, Modeling, using the FCI, implementing the Learning Assistant model, and much more.

## Nominations for Awards and Fellowship are Needed

*Larry Cain, Davidson College, Past Chair of FEd*

As the past chair of the Forum on Education, which means I am chair of the FEd Fellowship Committee this year, I want to encourage you to think about nominating persons this year for the APS education-related awards under FEd's care and for APS Forum on Education Fellowship. Specifically, please consider the **Excellence in Physics Education Award** - to recognize and honor a team or group of individuals (such as a collaboration) or, exceptionally, a single individual, who have exhibited a sustained commitment to excellence in physics education; the **Jonathan F. Reichert and Barbara Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction** - to recognize and honor outstanding achievement in teaching, sustaining (for at least four years), and enhancing an advanced undergraduate laboratory course or courses at US institutions; and the **APS Forum on Education Fellowships** - to recognize exceptional contributions to physics education. Fellowship is a distinct honor signifying recognition by one's professional peers. Nomination instructions for these two awards and fellowship can be found at the APS Honors website: [aps.org/programs/honors/index.cfm](https://aps.org/programs/honors/index.cfm). Nomination deadlines are 6/3/2019. Please consider a diverse set of people to nominate, including women, members of underrepresented minority groups, and people at smaller institutions.

The selection committees typically receive a small number of nominations for these awards and for fellowship. Please consider taking the time to prepare a nomination. Nominations typically include: A suggested citation, a nomination letter, two to four letters of support, a CV, and most important publications and reprints. The time spent to prepare a nomination is well worthwhile to those nominated, to the Forum and to APS.

The American Physical Society's (APS) Committee on Education (COE) seeks to recognize excellence in undergraduate physics education and support best practices in education at the undergraduate level by accepting applications from physics departments and/or undergraduate-serving programs in physics for the **COE Award for Improving Undergraduate Physics Education**. All programs that have a significant impact on undergraduate physics students are eligible to apply. Application instructions can be found at [aps.org/programs/education/undergrad/faculty/award.cfm](https://aps.org/programs/education/undergrad/faculty/award.cfm) and the deadline is 6/15/2019.

We all know of deserving colleagues for these awards and for fellowship, but we must submit nominations for them to be considered.

## Director's Corner

*Theodore Hodapp*

### How do we learn to be mentors?

I recently had the unfortunate occasion to read direct comments from graduate students at a number of universities that were conducting APS Climate Site Visits. These visits, sponsored by the APS Committee on the Status of Women in Physics and the Committee on Minorities are a sort of external program review, but with a singular focus on the climate for women and/or minorities in the department. As a part of these visits, we send a survey to all graduate students and ask a number of questions that help reveal the underlying emotions and concerns of this group.

Reading these comments, mostly from women, was alternately awe inspiring and devastating. They spoke of the relationship with their research advisor. Many felt this individual “launched” their career, helped them understand the intricacies of independent research, and would be a life-long collaborator or colleague. Some, however, expressed how this relationship had made them hate physics. Hate. Physics.

This sort of devastation does irreparable harm to an individual. To me it cuts deep into my own personal feelings of how physics can be a positive force for understanding the universe and our relationship with that world view. I think to myself, how is it that we as a community allow such harm to be done? Or, as an educator, how are we providing support for mentors and advisors to improve their skills in this area? We now help new faculty learn how to be more effective in the classroom at helping their students learn through programs like the [New Faculty Workshop](#), but we

are still fairly absent from the discussion of the importance of this mentor-mentee relationship and providing support that can help improve these experiences.

The APS is starting to take some steps in this direction. In the extension of the [APS Bridge Program](#) (the broader effort now labeled [IGEN](#), or the *Inclusive Graduate Education Network*), we received funding from the NSF to partner with [CIMER](#) (*Center for the Improvement of Mentored Experiences in Research*) to build research mentor training materials – in this case for the mentors of new postdocs entering National Labs. APS is also in the process of updating its [ethics statement](#), and will be working with the committees on education, women, and minorities, among others, to help inform a new standing APS committee on ethics. Part of the charge to this committee is to “develop, maintain and disseminate materials” that will support and inform how we foster productive and positive professional relationships.

We have a ways to go but recognizing the problem rather than sweeping it under one of our professional rugs is a good first step. How do we take the next step? What is the role of the Director of Graduate Studies in the health of these relationships? Or, the role of the larger graduate faculty? What strategies do we develop and propagate to improve the experiences for all students – especially those who enter studies, full of the excitement about the power of physics to help us understand the universe, only to leave full of resentment? We need to do better. Let me know what you think ([hodapp@aps.org](mailto:hodapp@aps.org)).

## Political Advocacy: Why now more than ever

*Scott Franklin, Rochester Institute of Technology*

The American Physical Society has long advocated at Federal and State levels, with some important results. APS contributed ideas that ended up in the 2009 American Recovery and Reinvestment Act of 2009, which awarded \$3B in funding to the National Science Foundation, much for “shovel-ready” science projects. More recently, APS advocated successfully that graduate student stipends should not be taxed as proposed in 2018 Tax Reform, contributed feedback that influenced wording on the 2018 National Quantum Initiative bill and has engaged (perhaps less successfully) with the Office of Science and Technology Policy (OSTP) on the STEM Education Strategic Plan. These result from a long, slow process in which APS staff *and members* cultivate relationships with members and staff on Capitol Hill, in the process learning which issues are germane to the representatives and senators and how best to communicate our priorities.

STEM Education issues of particular importance to the Forum on Education are also being discussed at the highest levels of APS. The Committee on Education has worked to establish the following priorities for APS education policy;

1. Ensure all high school students have access to a year of high quality physics
2. Promote widespread use of evidence-based education practices throughout the undergraduate physics curriculum
3. Increase the participation in physics in the broadest possible ways

Currently, an Education Policy Committee is considering additional priorities and welcomes community input into this process. I am the FEd representative on this committee and invite you to contact me for direction for more information on this process.

Forum members can play a critical role in advancing these priorities, and this article explores why, how and where you can help. Whether your motivation to advocate is personal, professional or moral, I have found advocacy to be timely, important, straightforward and *lots of fun*.

### Why Advocate

The professional case for advocacy has never been clearer. The current administration has proposed large cuts in funding for STEM and STEM education, removed “evidence-“ and “science-based” language from government websites, and terminated reports on environmental impact and climate change. In early July the administration moved to revise federal guidelines for academic institutions considering race in admissions and Supreme Court. Chief Justice John Roberts’ question in *Fisher v. University of Texas* of “What unique perspective does a minority student bring to a physics class?” still rankles. For some depressing reading, check out the Union of Concerned Scientists running list of attacks on science at [ucsusa.org/center-science-and-democracy/attacks-on-science](http://ucsusa.org/center-science-and-democracy/attacks-on-science).

Nevertheless, some strong bipartisan support for science exists and should be recognized. When the Trump administration requested an 11% budget cut to the National Science Foundation, the Republican-led Congress instead returned a 4% increase. Similar stories played out for NIST (26% increase instead of the requested 23% cut), the Department of Energy’s Office of Science (16% increase instead of 17% cut) and NIH (9% increase instead of 22% cut). The administration proposed eliminating all STEM Education programs; *Congress fully funded every one*. I don’t mean to suggest that the two political parties are equivalent. But the local nature of legislative politics ensures that representatives attend to issues relevant to their constituents and STEM, STEM Education and job preparation all resonate.

For example, my first visit to Capitol Hill in 2010 was with a tea-party Republican representative from upstate New York. Nevertheless, because of his district workforce needs, he was one of only 16 Republicans to vote for the America COMPETES Reauthorization Act of 2010 that continued funding of STEM research. Despite our many differences of opinions, we had a successful meeting that led to continued contact over several years. And, because of this, we were able to find areas of common interest. For example, in 2011 his Legislative Assistant reached out to me for input on intellectual property resulting from scientific research and development, an issue germane to academics and industrial scientists.

The recent elections in which the Democrats regained control of the House creates new opportunities, especially in the House Science Committee, often the focal point for science policy debate. Rep. Lamar Smith (R-TX) who had an often adversarial relationship with the National Science Foundation, challenging the peer-review process, climate science and environmental policy is now replaced by Rep. Eddie Bernice Johnson (D-TX) who has intro-

duced a bill to promote research “at the water-energy nexus” and has stated her intent to “address the challenge of climate change, starting with acknowledging it is real, seeking to understand what climate science is telling us, and working to understand the ways we can mitigate it.”

There are, of course, non-professional issues that cry out for engagement as well: immigration policy, federal minimum wage, climate change and environmental regulations, military spending and foreign or tax policy. Whatever your motivations, Capitol Hill is a place where you can make your voice heard to the people closest to “the room where it happens.”

### How to Advocate

Getting an appointment, either on Capitol Hill or at your representative’s local office, is surprisingly easy. Simply call your representative’s office (numbers can be found at [whosmyrepresentative.gov](http://whosmyrepresentative.gov)), explain your issue(s) and ask to meet with an aide. Each office has a staff of aides, each with their particular issues, and sitting down with constituents is an important part of their job. Grab a suit or equivalent and you’re set.

Aides range from just-out-of-school interns to more experienced staffers who have been on the Hill or with the representative for years. Don’t be fooled by their age, however. Aides are incredibly smart, driven and well-informed on their particular issue. While they may not know STEM-specific details, they have a perspective on how individual issues fit together both within the national context and the representative’s philosophy.

This big-picture perspective results in an interesting twist: *communication on the Hill is the inverse of scientific dialogue*. Scientific arguments are a chain of logical ideas that build to a conclusion. But on Capitol Hill, no issue is independent of another and straightforward logic may not suit the complexity of multiple intersecting issues. It is therefore better to present your issue or “ask” first and then listen to get an idea of what information the aide thinks most useful or interesting. Leading with an ask (e.g. “Hi, my name is Scott and I’m here to ask you to consider exempting graduate stipends from tax.”) can seem a bit presumptuous but aides expect visitors to ask for something and doing so up front is seen as respectful of their time, not rude.

Finally, share your personal stories and *have fun*. Offices love to hear about what’s going on in their district or state so bring the impact down to the personal level and how things affect you the constituent. Show your passion and excitement. Talk about how the issue is important to you, how STEM policy impacts your classrooms and labs, and how your work contributes to the local workforce or develops students. I have also found it particularly effective to bring students with me to advocate for themselves. Graduate students present compelling testimony for inclusive visa and immigration policy. Undergraduate students can talk about Pell grants and other policy that has enabled their studies.



It has now become part of my conference planning to, whenever possible, add a day to any DC travel to visit the Hill. Sometimes I'm just touching base with my personal Senators and Representative. Other times I'll reach out to APS or AiP to see if there are any current issues they want advocated and, if appropriate, I will visit offices of relevant non-NY Representatives. I've now advocated, with help from APS and AiP, for a range of STEM and STEM-Education policies, including preserving the peer-review system at NSF, waiving taxes on graduate student tuition, and the importance of sustained funding at national labs. I found this process incredibly educational and enjoyable, and recommend everyone experience the thrill of walking through the halls of our government at least once.

### When and Where to Advocate

There's never a bad time to advocate. If you have a few hours in D.C., make an appointment and visit your representative. Meetings are typically 10-15 minutes, so scheduling an hour per visit is appropriate. Each representative also has a local office in major towns or cities. Advocating there or at town halls when representatives are in town can be particularly effective ways to get involved with their local efforts.

## Modeling Instruction – transforming science education nationwide

*Jane Jackson, Arizona State University and David Hestenes, Arizona State University*

High school physics is the chief pathway to college STEM majors and STEM careers. STEM jobs are growing twice as fast as other fields. Yet we are far from the AAPT goal of “physics for all,” partly because the U.S.A. has a severe shortage of qualified physics teachers. Professional development (PD) in physics for teachers is thus crucial. A healthy economy and society require physics.<sup>1</sup>

Modeling Instruction is an effective way to teach; it strengthens the STEM pathway and improves scientific and mathematical literacy. Workshops are ongoing nationwide, and teachers can participate both for skill development and becoming more active in a community of teachers.

Modeling Instruction was developed by Arizona State University (ASU) physics professor David Hestenes and Malcolm Wells, a veteran high school physics teacher in ASU's city of Tempe, Arizona. It corrects many weaknesses of the traditional lecture-demonstration method, including fragmentation of knowledge, student passivity, and persistence of naive beliefs about the physical world.

The ASU Modeling Instruction Program was funded from 1990 to 2005 with grants from the National Science Foundation. It was institutionalized at ASU in 2001 as a summer graduate program

There are many resources that can help you prepare. The American Physical Society has created an advocacy dashboard ([aps.org/policy/issues/index.cfm](https://aps.org/policy/issues/index.cfm)) on which STEM Education is highlighted. The American Institute of Physics's FYI website ([aip.org/fyi](https://aip.org/fyi)) is a compilation of news and resources for federal science policy, and allows you to track budgets and bills, look up representative positions and get summaries of the week's congressional activities. APS and AiP both maintain DC offices that are willing to spend time to help you prepare for your visit. Depending on the time of year and what issues are topical they may even accompany you on your visit and/or supply you with supportive materials. In that vein, I would like to take this opportunity to thank Greg Mack for his work coordinating and facilitating member visits from the the APS DC Policy office.

Good luck and have fun!

*Scott Franklin is a Professor of Physics at Rochester Institute of Technology and Director of the Center for Advancing STEM Teaching, Learning & Evaluation. He maintains active research labs in both physics education and granular materials and has been advocating on Capitol Hill, independently and as part of APS-coordinated events since 2010.*

for science teachers.<sup>2</sup> It is primarily for lifelong PD and is the foundation of the ASU Master of Natural Science (MNS) degree for physics and chemistry teachers. Up to 75 teachers participate each summer. Singapore, tops in the world in student international science tests, has sent 54 physics and chemistry teachers in 12 summers. The program is crucial to remedy chronic shortages of physics and chemistry teachers in Arizona.

Modeling Instruction at ASU was rated an Accomplished STEM program by *Change the Equation*, a coalition of Fortune 500 CEOs, in 2015. Modeling Instruction was designated as an Exemplary K-12 science program and a Promising K-12 educational technology program by two expert panels of the U.S. Department of Education. It received the 2014 Excellence in Physics Education Award by the American Physical Society.<sup>3</sup>

Modeling Instruction has expanded nationwide under direction of the American Modeling Teachers Association (AMTA) – a 501(c)(3) nonprofit established in 2005 by teachers to ensure sustainability of Modeling Instruction. Biology and middle school Modeling Workshops are held; astronomy and earth science Modeling Workshops are being developed now. In a typical summer, the AMTA coordinates 60 multi-week Modeling Workshops at 30 sites in 20 states, serving 1000 high school and middle school science teachers. A few online courses are held during the school

year. An online support system provides year-round help. As of 2018, more than 10,200 teachers in 49 states, including at least 10% of physics teachers nationwide, have taken Modeling Workshops and become more effective STEM educators.

Currently, a big obstacle for most public school teachers is that teachers must pay registration (typically \$750), making Modeling Workshops unaffordable. Up to ten years ago, most Modeling Workshops were grant-funded; however, since then the federal government has restricted funding to high poverty schools, and finally ended ALL competitive grant programs for teacher PD. (Federal Title II funds for teacher PD are states' and school districts' responsibility. As of 2016, no Title II funds are set aside at state level for higher education faculty grant competitions for K-12 teacher PD. Most physics teachers cannot access school district Title II funds, as physics competes with all other K-12 subjects and grade levels. Also, federal and state Math and Science Partnerships programs have been discontinued. Nothing is left.)

If the U.S.A. is to maintain its global competitiveness, it must act on research showing that high school physics is the chief STEM pathway. Long-term teacher PD in physics and other sciences is essential to improve student learning; ten years of deliberate practice are needed to become an expert, research shows. Thus teachers need several Modeling Workshops.

Modeling Workshops empower teachers to be effective. In a series of intensive three-week workshops over two summers, teachers improve their physics, chemistry, or biology content knowledge. They are equipped with a robust teaching methodology for developing student abilities to make sense of physical experience, understand scientific claims, articulate coherent opinions of their own and defend them with cogent arguments, and evaluate evidence in support of justified belief; i.e., **students become scientifically literate.**

Students in Modeling Instruction classrooms experience firsthand the richness and excitement of learning about the natural world. They transfer their knowledge to daily life. One example comes from Phoenix modeler Robert McDowell. He wrote that, under traditional instruction, “when asked a question about some science application in a movie, I might get a few students who would cite 1-2 errors, but usually with uncertainty. Since I started Modeling, the students now bring up their own topics... not just from movies, but their everyday experiences.” One of his students wrote, “Mr. McDowell, I was at a Diamondback baseball game recently, and all I could think of was all the physics problems involved.”

Explore, explain, apply (in that order): Classroom instruction is organized into two-week modeling cycles that engage students in building scientific models, evaluating them, and applying them in concrete situations. Rather than lecture, the teacher guides the class to ask questions of nature. To answer the questions, teams of students design experiments and use the computer to gather

data. From their data they construct mathematical models and defend them to the class. They apply models to different situations. The course becomes coherent because it is centered on a few basic models. It brings the classroom closer to the workplace because modeling is a central activity of scientists, engineers, and many in business.<sup>4</sup> It is a prime implementation of *interactive engagement*, the cognitively most effective teaching strategy. Short videos of classroom instruction have been produced by public media – we recommend the 12-minute WNET production, [ny.pbslearningmedia.org/resource/npe11.pd.sci.modapp/a-modeling-approach-to-physics-instruction/](http://ny.pbslearningmedia.org/resource/npe11.pd.sci.modapp/a-modeling-approach-to-physics-instruction/).

Modeling Instruction is a curriculum *design*, rather than a fixed curriculum; thus teachers can flexibly adapt it to different courses and student abilities. Instructional materials developed for the regular/core first year physics course have a proven track record, as they have been used by physics teachers all over the nation since 1995. Sample physics materials (excluding evaluation instruments) are freely available at the [AMTA website](http://AMTA website).

The effectiveness of Modeling Instruction has been evaluated with well-established standardized instruments, chief among them being the Force Concept Inventory (FCI).<sup>6</sup> Our FCI data for 20,000 high school students nationwide, most in regular first year physics, reveal that student learning gains under Modeling Instruction are typically double those under traditional instruction. Student FCI gains for “ordinary” Arizona teachers, three-fourths of whom were not physics majors, are almost as high as those for leading teachers nationwide. Teachers who implement Modeling Instruction most fully have the highest student posttest FCI mean scores.

**Modeling Instruction has proven successful with students who have not traditionally done well in science, while enhancing the performance of all students.** Teachers report improved achievement on ACT science and AP physics tests, higher enrollment in advanced high school science electives, more STEM majors in college, and enhanced achievement in college courses (across the curriculum!).

Modeling Instruction aligns with the Next Generation Science Standards (NGSS). The National Research Council (NRC) book, *A Framework for K-12 Science Education*, is the research basis for NGSS. Emeritus physics professor Helen Quinn of Stanford University, chairman of the NRC committee that authored the *Framework* book, told David Hestenes later that what was written about modeling there was informed by Modeling Instruction. A nationwide survey showed that “on average, high school teachers who have completed 90 hours of professional development in Modeling Instruction (a 3-week summer workshop) feel significantly more motivated and better prepared for NGSS than high school teachers who are non-Modelers.”<sup>7</sup>

Modeling Instruction originated in calculus-level physics at Arizona State University. Several post-secondary institutions now use Modeling Instruction, notably Florida International Univer-

sity, Drexel University in Philadelphia, and Estrella Mountain Community College in Avondale, Arizona.<sup>8</sup> Eugenia Etkina, developer at Rutgers of the Investigative Science Learning Environment (ISLE) for college and high school physics, agrees with us that ISLE and Modeling Instruction are super-compatible.<sup>9</sup>

*Jane Jackson has co-directed the Modeling Instruction Program in the ASU Department of Physics since 1994, after teaching post-secondary physics for 18 years. [jane.jackson@asu.edu](mailto:jane.jackson@asu.edu)*

*David Hestenes is Emeritus Professor of Physics at ASU. His research is in foundations of physics, physics education, and mathematical physics -- specifically Geometric Algebra, a unified mathematical language for physics.*

### (Endnotes)

1. A discussion with research references is at <http://modeling.asu.edu/modeling/STEMpathways-Physics.htm>.
2. Hestenes, D., Megowan-Romanowicz, C., Osborn-Popp, S., Jackson, J., & Culbertson, R. (2011). A graduate program for high school physics and physical science teachers. *American*

*Journal of Physics* 79(9), 971-979.

3. These awards, NSF grant findings, research and evaluation (& FCI), and resources for teachers who use Modeling Instruction are at [modeling.asu.edu](http://modeling.asu.edu). See also the AMTA website: [modelinginstruction.org](http://modelinginstruction.org)
4. Jackson, Jane, Dukerich, Larry, & Hestenes, David (2008). Modeling Instruction: An Effective Model for Science Education, *Science Educator* 17(1): 10-17.
5. Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist*, 49, 219-243.
6. [physport.org/assessments](http://physport.org/assessments)
7. Haag, S., & Megowan, C. (2015). Next Generation Science Standards: A National Mixed-Methods Study on Teacher Readiness. *School Science and Mathematics*, 115(8), 416-426.
8. Weblinks to resources are at [modeling.asu.edu](http://modeling.asu.edu) in the section called "Modeling Instruction in College".

## Scaling up Educational Change: The TRESTLE Initiative

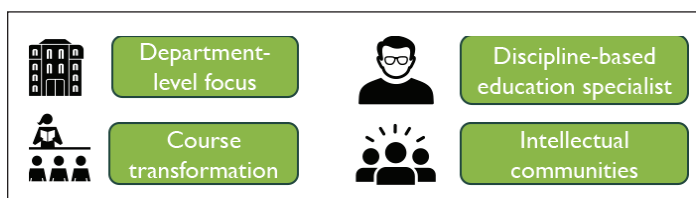
*Stephanie Chasteen, University of Colorado Boulder*

Imagine a faculty member – let’s call him Bob – who feels like he wants to shake things up in his course. Maybe he was inspired by ideas he heard at the New Faculty Workshop offered by AAPT/APS/AAS, or at the teaching and learning center on campus. Bob talks to a few colleagues in the department to figure out students’ biggest struggles. Maybe he writes some clicker questions, or makes up a worksheet for students. How does he figure out how to design the activity well? How will he know if it worked, and how to improve it? How does Bob persist in the experiment, given all the duties of a working professor? Wouldn’t it be great if Bob could find someone to act as an *intellectual partner*, to discuss student difficulties and possible teaching approaches, review the activity, and help assess its effectiveness? After all, once Bob figures out some crackerjack approaches in this course, he could then apply them to his other courses, and perhaps share the ideas with his fellow faculty.

For the past decade I have been involved in two initiatives at the University of Colorado Boulder which have aimed to support such substantive, discipline-based intellectual partnerships around teaching: The Science Education Initiative (SEI) and the Transforming Education, Stimulating Teaching and Learning Excellence (TRESTLE) project. The goal of both the SEI and TRESTLE is to empower STEM faculty and departments to use effective educational techniques more broadly.

Both initiatives have at their heart four main design principles:

1. **Department-level focus.** Activities are centered in individual STEM departments, like physics.
2. **Course transformation** as the core activity, to help faculty try out new educational techniques.
3. **Embedded discipline-based education specialist (DBES);** we give faculty access to a human who is expert *both in the discipline and in education* to provide intellectual partnership and help that is targeted to the specific issues of the discipline.
4. **Intellectual communities;** communities among the educational experts, faculty, departments, and (in the case of TRESTLE) institutions help spread and grow expertise around teaching and learning.



Why do we feel these design principles are so important for achieving educational change? The department-level focus is valuable since departments are the seat of educational activity; they direct



curriculum and courses, and serve as faculty members’ professional home. By focusing activity on course transformation, it is easier to get the time and attention of busy faculty members (like Bob), and faculty get authentic opportunities to experiment within the context of their course and learn what works along the way.

A hallmark of the SEI and TRESTLE initiatives is the use of discipline-based education specialists (DBESs), who may be postdocs, instructors, or faculty, embedded directly within departments. Rather than leaving Bob on his own to figure out the best techniques and assess their effectiveness, he gets access to an expert who combines the disciplinary expertise of their physics colleagues, and the pedagogical expertise of a teaching-and-learning expert, who can give very targeted intellectual partnership and help to Bob – as well as valuable time to do some development and assessment.

Most of these ideas grew up with the first initiative, the Science Education Initiative, the brainchild of Carl Wieman. (See Wieman<sup>1</sup> for a full description of the SEI, and Chasteen and Code<sup>2</sup> for a practical guide to creating such initiatives). The SEI was implemented at the University of Colorado Boulder and University of British Columbia, and hired several postdocs to act as DBESs in 7 departments at each institution. A department director oversaw activity in each department, and a central organization coordinated the initiative across departments. I was originally hired as one of these postdocs; I learned about education and educational assessment from SEI Central staff, partnered with physics faculty to transform our upper-division E&M course, and met weekly with other such postdocs to share ideas and lessons learned. These initiatives lasted about a decade and involved 25-50 postdocs at each institution, and so were quite expensive – funded by each institution, they cost an average of \$650K (at CU Boulder) and \$1.4M (at UBC) per department.

The TRESTLE initiative grew out of an adaptation of the SEI model developed at the University of Kansas, in an attempt to answer the question, “Can we propagate change through more limited resources using networked communities?” TRESTLE uses fewer discipline-based education specialists, focusing more explicitly on

building [networked communities](#) – communities of people joined by a common approach to addressing complex problems. These communities are being built among the project leaders, educational experts, and faculty, on and across campuses. TRESTLE is a networked community of 7 institutions (most of whom are members of the [Bay View Alliance](#) network of universities), directed out of the University of Kansas and funded through the NSF. All TRESTLE partners are dedicated to using department-based embedded experts, building communities within and across institutions, and generating visible evidence of these impacts to document change and establish norms to motivate further change. All campuses use common measures of impact (e.g. course-specific assessments, faculty surveys, course observations, course statistics, and qualitative case studies).

Each campus is free to apply the overall model in the ways that best fit their local context. For example, at CU Boulder we chose not to use individual postdocs again but instead to try to leverage the existing faculty expertise on campus. Initiatives such as the SEI and the Learning Assistant program (which uses talented undergraduates as facilitators of learning; [learningassistantalliance.org](#)) and other innovations like the PhET Interactive Simulations ([phet.colorado.edu](#)) have resulted in a wealth of faculty expertise about teaching and learning on campus. TRESTLE aims to empower those faculty to lead course designs and faculty communities. Other TRESTLE campuses have used a variety of context-dependent variations of the model; see below.

How is it going so far? We can say that TRESTLE is affecting multiple departments, and the involved courses are more student-centered. We have also learned that supporting the independence of each campus and its’ project is challenging (while maintaining a coherent project vision). We are also finding that there seems to be a national need for such collaborations, and many people are eager to find a community for DBESs and others who partner with faculty.

**How can you use what we have learned?**

*If you are an individual faculty member*, there are two things you could learn from our experience. First, your courses are a fertile

Types of embedded discipline-based educational specialist (DBES)	Community-building efforts
<ul style="list-style-type: none"> <li>• Multiple postdocs in multiple departments.</li> <li>• Individual postdoc in one or more departments.</li> <li>• Faculty leaders redesigning their own courses.</li> <li>• Faculty leaders guiding faculty colleagues in course redesign or leading faculty learning communities.</li> <li>• Graduate students or faculty in the Education department</li> </ul>	<ul style="list-style-type: none"> <li>• University-wide teaching consortium.</li> <li>• Regular events or gatherings (such as Science Suppers).</li> <li>• Reading groups.</li> <li>• Regular meetings of postdocs.</li> <li>• Faculty learning communities.</li> <li>• Department teams.</li> <li>• TRESTLE network-wide virtual meetings and colloquia.</li> <li>• TRESTLE network-wide in-person annual meetings.</li> </ul>

crucible for experimentation. We have much written for you on what works in course design on our [SEI instructor guidance pages](#). Second is to seek intellectual partnership from others in your department or beyond – you may be able to be creative and hire a postdoc or grad student (with a background in education) with an expectation that some of their time will be spent on educational change, or fund an existing postdoc to work on your course with you for a semester.

*If you are someone who partners with faculty on course design* (either as a postdoc, instructor, or physics education research faculty), there are many recommendations for you on how to be successful in this role in our SEI Handbook,<sup>2</sup> at [pressbooks.bccampus.ca/seihandbook/](#), such as how to partner with faculty, giving effective feedback, and developing your own professional expertise. And join the TRESTLE email list to connect with our cross-campus community, at [trestlenetwork.org](#)!

*If you want to start an initiative in your department or campus*, our 4 design principles can be flexibly adapted to your individual situation to attempt to spread change with modest means. Again, the SEI Handbook<sup>2</sup> also has many valuable lessons learned for initiative directors, such as soliciting proposals, identifying departments for inclusion, and training educational specialists.

### To learn more

SEI: [cwsei.ubc.ca](#) and [colorado.edu/sei](#)

TRESTLE: [trestlenetwork.org](#)

TRESTLE@CU: [Colorado.edu/csl/trestle](#)

This is based on work funded through NSF DUE 1525775, DUE 1525331, DUE 1525345.

*Stephanie Chasteen is at the University of Colorado Boulder, where she is the Director of the TRESTLE Initiative @ CU and Associate Director of the Science Education Initiative. She conducts research and evaluation on STEM educational initiatives, with a focus on departmental change and faculty use of research-based teaching methods, and provides external evaluation for a variety of projects such as PhysTEC and Effective Practices for Physics Programs (EP3). More about her independent work at [chasteenconsulting.com](#).*

### (Endnotes)

1. Carl E. Wieman. “Improving How Universities Teach Science: Lessons from the Science Education Initiative,” Cambridge, MA: Harvard University Press, (2017).
2. Stephanie V. Chasteen and Warren J. Code. (2018) “The Science Education Initiative Handbook.” Accessed at [pressbooks.bccampus.ca/seihandbook/](#), (2019).



## Teacher Preparation Section

*Alma Robinson, Virginia Tech*

As part of the overarching theme to disseminate actions that we can take to improve science education, this issue of the Teacher Preparation Section will highlight ways that preservice programs can prepare their future physics teachers to be effective inside and outside of the classroom.

A perfect confluence of this theme and teacher preparation is the Learning Assistant (LA) model of using undergraduates to help teach science courses. Not only do LAs positively impact student learning, these programs can also serve as a catalyst for LAs to consider teaching as a career, and even encourage faculty to adopt student-focused pedagogies. Andrea Van Duzor and Mel Sabella

describe LA training, how LAs can facilitate student learning, and how faculty can learn more about implementing LA programs by attending an LA workshop and joining the Learning Assistant Alliance.

Kelli Warble discusses how her experience with a task force convened by the American Association of Physics Teachers helped her understand the importance of involving teachers with policy issues. By preparing our teachers to see how education policy affects their classrooms, they can learn how to better advocate for their students and themselves.

## The Learning Assistant Model as a Scaffold for Instructional Change and Student-faculty Collaboration

*Andrea Van Duzor, Chicago State University and Mel Sabella, Chicago State University*

In the Learning Assistant Model, undergraduate students serve as Learning Assistants (LAs) in the classroom and facilitate the learning of their peers. LAs are typically placed in courses that they have successfully completed and act as “master learners” who can model questioning and answering strategies and guide small groups in problem solving sessions. They are not “teaching assistants,” who often take on instructor responsibilities, rather, they serve to support student learning in the classroom. In addition to classroom practice, other key elements of the LA model include a pedagogy course, a weekly meeting with a faculty mentor, and continuous reflection on the teaching and learning of the subject throughout. These elements provide substantial support to LAs as well as unique opportunities for collaboration and partnerships between undergraduates (LAs) and faculty that can have a deep impact on a program’s or institution’s instructional environment. The LA model can scaffold discussions between students and faculty, capitalizing on their diverse expertise and experiences, as they actively pursue best practices in the classroom.

### LA program outcomes

The central focus of the LA program is improved learning outcomes for students in the LA supported classes. In concert with student-focused pedagogies, the LA model can increase student-learning gains. LA programs also have a large impact on the LAs themselves. In addition to reinforcing an LA’s own content understanding, programs using the LA model have been shown to create positive shifts in overall LA attitudes about science, personal interest, and content knowledge. Serving as an LA can facilitate a student’s growth of their identity as a scientist and in their inclusion in the scientific community of practice. Additionally, the LA model can promote the pursuit of teaching as a career, and new teachers who had served as LAs use reformed teaching practices more often than their peers in the same teacher preparation program who did not have an LA experience. A critical component of the LA model is that it can be transformative not only to students and the LAs who participate, but it can also impact faculty, as they work toward transforming their courses to be able to effectively utilize LAs.

### Role of faculty in LA programs

The LA model can have deep impacts on instructional environments, too, as it can foster a rich collaborative space where LAs are invited to play a role in creating active and inclusive learning environments that build on local strengths. As noted previously, the LA model is comprised of three key elements: a pedagogy course, weekly faculty meetings, and classroom practice. The pedagogy course is usually taught by the LA program coordinator. It introduces students to both theoretical topics, such as mental models and metacognition, and practical topics, such as question-

ing strategies and group dynamics, as well as providing space for reflection on practice. However, it is in concert with the weekly meetings with faculty and in the classrooms where LAs can help shape instruction.

Faculty are typically expected to lead the weekly meetings and direct classroom practice. While a small LA Program, like at Chicago State University (~20 LAs), may include one-on-one weekly meetings where the LA talks directly to the instructor of the course, large LA Programs, like the University of Colorado-Boulder (~300 LAs), where the LA Model originated, might have twenty LAs and TAs in a weekly meeting with a faculty member. These meetings depend on the LA and faculty preparation in, and views on, science content, pedagogy, and partnerships, as well as their time constraints for meeting. Weekly meetings can potentially provide a collaborative space where LAs and faculty can collectively think about the best ways to support students.

Faculty-LA interactions within the weekly meeting can be categorized along a continuum of mentor-mentee relationships, faculty driven collaborations, and collaborative partnerships. In mentor-mentee relationships, the focus is on teaching the LA and ensuring they understand the content. Faculty driven collaborations make room for LA input and reflection, but curricular choices are still faculty determined. Collaborative partnerships allow for faculty and LAs to co-analyze student learning and co-generate classroom activities. While weekly meetings may focus simply on content preparation, they have the potential to do much more. Collaboration with LAs in the weekly meeting and in the classroom can enable faculty to make large impacts on their instruction and student learning. Indeed, in examining a sample of over 3315 physics students’ conceptual pre-post test scores, Van Dusen et al. found that for every term a faculty member had taught a course with an LA, there was a statistically significant 0.154 increase in effect size on student learning gains.<sup>4</sup> Having LAs allows faculty to increase their use of student-focused pedagogies, try new strategies and curricula, voice their pedagogical choices, and receive real-time feedback.

### Faculty development and support

The Learning Assistant Alliance (LAA) provides resources for faculty and program coordinators seeking to design, develop, expand, and sustain LA programs. Faculty can find guidance on how to use LAs effectively in the classroom, facilitate productive weekly meetings, and adopt and adapt student-focused pedagogies and curricula on the LAA website: [learningassistantalliance.org](http://learningassistantalliance.org). Videos, articles, rubrics, and guidelines are presented. Additionally, online assessments, accessible to faculty at institutions with or without a LA program, are available through the LAA by using the Learning About STEM Student Outcomes (LASSO)

online platform. The upcoming LA workshops listed below will provide hands-on professional development for faculty and institution teams:

- March 8-9, Front Range Community College and University of Colorado-Boulder, in Boulder, CO will co-lead a workshop emphasizing 2-year/4-year institutional partnerships.
- April 27-29, the University of Maryland in College Park, MD, will host a workshop with special attention to using LAs in engineering courses.
- June 14-15, St. Cloud State University in St. Cloud, MN will present a workshop specializing on faculty development, administrative support, and institutional partnerships.

More information on registration is available through the Learning Assistant Alliance website. Workshops provide faculty with supportive space to think deeply about course transformation and LA support. Over 70 institutions have instituted LA programs, and organizations such as PhysTEC and NSF have supported dissemination of the model because the LA Model has served to improve student learning, promote growth in the LA's content understanding and scientific identity development, and encourage faculty development and course transformation.

*Andrea Van Duzor and Mel Sabella are faculty in Chemistry and Physics, respectively, in the Department of Chemistry, Physics, and Engineering Studies at Chicago State University. Both conduct education research involving undergraduate STEM majors, and they co-direct the university's Learning Assistant Program. At the national level, they are active in resource development and governance of the Learning Assistant Alliance. Sabella is President of the American Association of Physics Teachers (AAPT).*

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# Should We Prepare Future Physics Teachers to Advocate for Effective School Policies?

*Kelli Warble, American Modeling Teachers Association and Arizona State University*

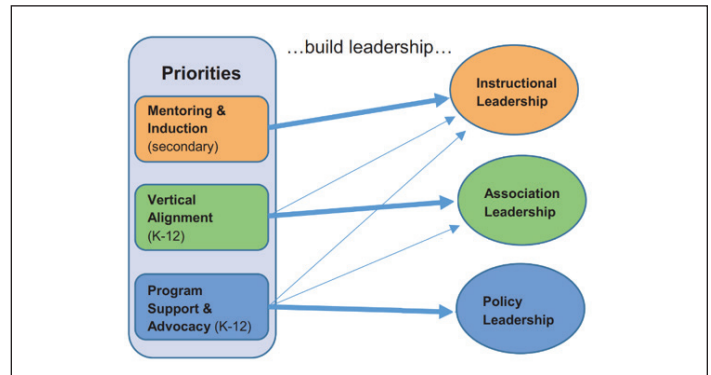
Recently I have been struggling to answer the following question: **Should physics teacher preparation programs educate future teachers about policy matters that are certain to affect their work as educators?**

Ten years ago, when I was still in my high school classroom teaching mathematics and physics, I would not have considered policy advocacy to be part of my duties. But my experiences since becoming the Physics Teacher in Residence at Arizona State University (ASU) have made me realize that teachers negotiate policy issues more often than commonly recognized. And many of these issues have a significant impact upon students.

Does a district require all physics courses to have a common assessment? Is a school considering whether to transition to block scheduling? Does the state require a certain number of science courses be completed for graduation? Are science classrooms being remodeled, and if so, are effective classroom practices being considered in designing the new layout?

These are all policy considerations about which teachers are **not** commonly consulted. Yet decisions about these issues have a huge impact on an educator’s ability to foster valuable learning experiences for students.

In late 2016, I was a member of a task force convened by the American Association of Physics Teachers (AAPT) to articulate ways to leverage physics teachers as agents of change in education. As we worked to identify characteristics of teacher leaders, we found three arenas that were influenced by the leadership of



**Figure 1:** Task force priorities build arenas of Teacher Leadership

exceptional educators (see Figure 1). The first two arenas were (to me) not surprising—instances of remarkable leadership in physics instruction and professional teacher associations. What I had not considered before was the potential for teacher leaders to affect policies at the local, state, and national levels.

Our task force subsequently collaborated on *Aspiring to Lead: Engaging K-12 teachers as agents of national change in physics education*,<sup>1</sup> a report released by the AAPT in 2017. This report became an inspiration to me: I began a graduate program to pursue a Master’s in Science and Technology Policy at Arizona State University. My studies led me to an internship with AAPT where I was privileged to work with Rebecca Vieyra (then the AAPT K-12 Program Manager) as she successfully spearheaded a new policy fellowship for teachers.

Policy Issue	My Initial Actions and Result	What I Might do Differently Now
Planning for a new structure to replace 75-yr-old rural high school facilities; teachers asked to meet with architects to articulate classroom wants and needs.	Shared ideal physics classroom layout, including movable stations that could be rearranged for group electronic data collection, whole- class discussion, or individual work. The final facility did not reflect teacher input and had identical fixed stations for all science classrooms.	Organize a meeting with all science department members prior to the appointment with architects. Discuss ideal facilities based upon content area and decide on a consensus plan. Meet with architects as a team to explain pedagogical reasons for facility requests.
Opening of a new high school in small rural district; planning for bell schedule and science course offerings.	Principal of new school opts for block scheduling while original school follows traditional scheduling. Science course offerings at new school follow different sequence than established school. Science department at original school took no action.	Consult with fellow science teachers about an ideal scheduling model and science sequence. Request time at next district board meeting to present options and advantages of cooperation between campuses. Advocate for common scheduling and science course sequence throughout the district.

**Figure 2:** Policy issues I confronted as a high school teacher and how I might handle them differently now.

The result was the first cohort of *AAPT/AIP Master Teacher Policy Fellows* selected in the spring of 2018.<sup>2</sup> I was honored to assist with a 10-day policy workshop for these teacher fellows in Washington, DC in July 2018. My experiences with this initiative caused me to re-examine my views about teachers as policy advocates and the role of teacher preparation programs in this arena.

I now recognize that many of my most frustrating experiences as a high school teacher centered on policy decisions that I felt helpless to address (see Figure 2). Had I been trained to recognize the importance of policy decisions and to advocate more effectively, would there have been different outcomes? Would this preparation have benefitted my students?

Although I am a novice to policy leadership, I was able to “mentor” several Arizona teachers by encouraging them to apply for the AAPT/AIP Policy Fellowship, and these teachers were subsequently selected for the program.

This group of Arizona teachers is now advocating to “Save Arizona Physics” and may potentially influence not only students in their individual classrooms, but also students throughout our state. Their experiences and reflections demonstrate insights that I aspire to stimulate in the pre-service physics teachers in our teacher preparation program at ASU.

The potential benefits of preparing teachers to become savvy to policy issues might best be reflected by the experiences of policy fellow Amanda Whitehurst. Amanda taught elementary and middle school science for 14 years and is currently on a break from teaching to raise her children. She recently became the President of STEMteachersPHX, a local group focused on networking and professional development for STEM teachers.

**Amanda:** “[I] want to talk...about the paradigm shift that happened over the course of our 10 days in DC. The big take-away is, as teachers, we already have the skills we need in order to effect change. We just need to make sure that we’re networking, that we are very prepared and knowledgeable,

and that we build a coalition of people who are all working towards the same goal. And in our state, that can seem like... an insurmountable task sometimes—but really, everybody **wants** to have good education...[but] they differ in how they want to accomplish that goal. We have to put a goal in front of them that everybody can agree on and find a path towards that goal.”

Amanda’s reflections spurred me to consider the benefits of including discussions of how policy decisions affect the physics classroom in our teacher preparation programs. Is it ethical to send teachers to the classroom without preparing them to advocate for policies that will ensure access to a high-quality physics education for all students? Is it appropriate for physics teachers to engage in policy debates?

In the final analysis, I worry that we, as a physics teaching community, must step up to advocate for effective policies for science education. Failure to do so risks continued implementation of policies which gradually degrade our ability to be effective educators.

*Kelli Warble has taught high school and college physics and mathematics for 25 years in the Phoenix area. She became the full-time physics Teacher in Residence (TIR) at Arizona State University in 2012. She currently serves as the TIR at Arizona State while pursuing a Masters’ degree in Science and Technology Policy. She is President Elect of the American Modeling Teachers Association.*

#### (Endnotes)

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2. American Association of Physics Teachers. (2017, May). K12 Programs-Aspiring to Lead. Retrieved June 1, 2018, from [aapt.org/k12/Aspiring\\_to\\_Lead.cfm](http://aapt.org/k12/Aspiring_to_Lead.cfm)

## Browsing the Journals

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

- Edmond Levy discusses matrix methods for solving the coupled differential equations for a sequential chain of radioactive decays on page 909 of the December 2018 issue of the *American Journal of Physics* ([aapt.scitation.org/journal/ajp](http://aapt.scitation.org/journal/ajp)). The same issue also has an article on page 934 titled “Will my student evaluations decrease if I adopt an active learning instructional strategy?” In half of the surveyed cases the answer is they actually increased, and in another third there was no change, and so instructors should not fear trying such teaching methods. On page 5 of the January 2019 issue, Alon Drory analyzes a rod thrown horizontally out of a moving train to show that accelerated objects cannot always be described as passing through a sequence of instantaneous comoving frames. The Computational Physics section in the same issue wrestles with the thorny issue of why multiplanetary solar systems do not collapse due to collisions between or ejections of planets.
- The November 2018 issue of *The Physics Teacher* ([aapt.scitation.org/journal/pte](http://aapt.scitation.org/journal/pte)) has a terrific photo on its cover of a ring of ice crystals formed as a cup of hot water is flung around when the air temperature is  $-20^{\circ}\text{C}$ . Another great photo on the last page shows the polarized transmission of skylight through a thin ice sheet after oblique reflection off a pool of water. A two-part article starting on page 516 of this issue discusses the physics of airplane lift in detail. I also enjoyed the personal reminiscences of falling in love with physics (“feezya”) as an Algerian middle-school student on page 559. An article on page 600 of the December issue helpfully explains the difference between plotting blackbody spectral intensity against frequency and wavelength by considering color bands rather than individual lines. In the January 2019 issue, an article on page 21 shows that experiments relating pressure to temperature using a Vernier sensor can be dramatically improved in accuracy by considering the extra volume of air trapped in the sensor and tubing. On page 40 of the same issue, Bob Hilborn provides a simple explanation of why potential energy (unlike kinetic energy) is a Galilean invariant.
- Article 065203 in the November 2018 issue of the *European Journal of Physics* considers some puzzles associated with two capacitors connected in series via a resistor when the initial charges on the two capacitors are different. Article 015204 in the January 2019 issue analyzes the voltages and forces between multiple charged pithballs hanging by equal-length threads from a common point of attachment. I also found Bokor’s diagrammatic analysis of a relativistic rocket to be enlightening in article 015603 of the same issue. Article 065004 in the November 2018 issue of *Physics Education* uses the uncertainty principle to estimate the Hawking temperature of a black hole. The well-known demonstration of the surprisingly large frictional force between interleaved books is reconsidered in article 015004 of the January 2019 issue. Both journals can be accessed online starting at [iopscience.iop.org/journalList](http://iopscience.iop.org/journalList).
- Lima has a helpful analysis of why the electric field at the surface of a charged conducting sphere is half of that just outside the sphere in the November 2018 issue of *Resonance*. It can be freely accessed at [ias.ac.in/listing/issues/reso](http://ias.ac.in/listing/issues/reso).
- Peter Lang discusses limitations of the usual model of a conductor as ions in a gas of free electrons on page 1787 of the October 2018 issue of the *Journal of Chemical Education*. On page 1989 of the November issue, the quantum mechanical bound states of a negative hyperbolic secant squared potential are presented. In the same issue on page 2041, laser polarimetry is used to measure scattering from a solution in an undergraduate lab. The journal archives are at [pubs.acs.org/loi/jceda8](http://pubs.acs.org/loi/jceda8).
- Article 020121 in *Physical Review Physics Education Research* at [journals.aps.org/prper/pdf/10.1103/PhysRevPhysEducRes.14.020121](http://journals.aps.org/prper/pdf/10.1103/PhysRevPhysEducRes.14.020121) investigates shortcomings in student understanding of bipolar transistors.



## Web Watch

*Carl Mungan, United States Naval Academy, <mungan@usna.edu>*

This issue ends exactly a decade that I have been writing this pair of columns three times a year for the Newsletter. However, it has been a long while since I have received any reader feedback about them. So it is high time to evaluate whether these columns have outlived their usefulness. Please email me your thoughts. Based on the comments I receive (or lack thereof), a decision will be made about whether these columns should be retired.



- *Undark* at [undark.org/](http://undark.org/) is a digital magazine devoted to issues at the intersection of science and society.
- The American Mathematical Society has a set of educational posters online at [ams.org/publicoutreach/mathmoments](http://ams.org/publicoutreach/mathmoments).
- You can browse Alan Nathan's site on the physics of baseball at [baseball.physics.illinois.edu/](http://baseball.physics.illinois.edu/).
- PLOS has a blog at [blogs.plos.org/scied/concerning\\_medical\\_science\\_education](http://blogs.plos.org/scied/concerning_medical_science_education).
- A useful compendium of online tools (such as dictionaries, drawing utilities, graphing calculators, PDF editors, and polling apps) is available at [grammarcheck.net/useful-online-tools/](http://grammarcheck.net/useful-online-tools/).
- Some conceptual and numerical implications of the relativistic rocket equations are presented at [math.ucr.edu/home/baez/physics/Relativity/SR/Rocket/rocket.html](http://math.ucr.edu/home/baez/physics/Relativity/SR/Rocket/rocket.html).
- Pictures of the Day are often fun. There's an optics one at [atoptics.co.uk/opod.htm](http://atoptics.co.uk/opod.htm) and an earth science one at [epod.usra.edu/](http://epod.usra.edu/).
- Increasing attention on scientific ethics has led to the formation of a searchable database of retracted science articles at [retraction-database.org](http://retraction-database.org).
- A visual and aural interactive exploration of waveforms is accessible at [pudding.cool/2018/02/waveforms/](http://pudding.cool/2018/02/waveforms/).
- The American Nuclear Society has an activities webpage for classroom educators at [nuclearconnect.org/in-the-classroom/for-teachers](http://nuclearconnect.org/in-the-classroom/for-teachers).
- A colorful exploration of airline international flight paths can be accessed at [multimedia.scmp.com/news/world/article/2165980/flight-paths/](http://multimedia.scmp.com/news/world/article/2165980/flight-paths/).
- AIP has put up decades of Melba Phillips correspondence at [repository.aip.org/islandora/object/nbla:AR2007746](http://repository.aip.org/islandora/object/nbla:AR2007746).
- I recently stumbled across an Indian journal titled *Physics Education* (not to be confused with IOP's journal of the same name) that is freely accessible at [physedu.in/](http://physedu.in/).
- A formula for generating Pythagorean triples (such as 5,12,13) is discussed at [maths.surrey.ac.uk/hosted-sites/R.Knott/Pythag/pythag.html#mnformula](http://maths.surrey.ac.uk/hosted-sites/R.Knott/Pythag/pythag.html#mnformula).



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**Upcoming newsletter deadlines:**

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